

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
San Joaquin District

SAN JOAQUIN VALLEY
DRAINAGE MONITORING PROGRAM
2000



District Report

September 2003

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FOREWORD

The purpose of this annual report is to share valuable information about agricultural drainage water. This report is distributed to interested parties to expand the understanding of drainage problem areas, groundwater impacts and water quality trends resulting from agricultural drainage practices.

The Drainage Monitoring and Evaluation Program is a cooperative effort of State, federal and local agencies. Data on the quality and quantity of drainage water and areal plotting of shallow groundwater are collected, assembled, analyzed, and disseminated. DWR collects shallow groundwater data and monitors about 30 drainage sump systems for flow and water quality constituents including sodium, calcium, total dissolved solids, selenium and other targeted constituents. The constituents are investigated for trends that show the results of irrigation and drainage management practices. Data from over ten other agencies are combined with DWR data and summarized in this report.

In addition, a shallow groundwater map is drawn from measurements of over 1,300 wells to show groundwater levels to identify present and potential problem drainage areas due to encroachment into the root zone of crops.

In comparison to the 1999 Drainage Monitoring Report, this report includes trend analyses and figures for the cations sodium, calcium, and magnesium. Furthermore, tables listing mineral analytical results for the central and southern area drains are relocated as separate appendices, whereas in past reports the mineral tables were part of the main body.

To improve its ongoing data-gathering efforts, the Department of Water Resources invites water resources specialists to participate in discussing and commenting on the scope of this report.

Paula J. Landis, Chief
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INTRODUCTION

In 1959, the California Department of Water Resources began monitoring agricultural drainage water in the San Joaquin Valley. Initial monitoring efforts (1959 to 1963) focused on mineral analyses. In 1963, the monitoring program became part of the San Joaquin Drainage Investigation and included analyses for pesticides both in surface and subsurface drainage waters. From 1966 to 1969, intensive nutrient sampling became a part of the investigation.

Although the San Joaquin Drainage Investigation ended in 1970, monitoring continued as a separate departmental activity until 1975 when the Department of Water Resources (DWR), the U.S. Bureau of Reclamation (USBR), and the State Water Resources Control Board (SWRCB) formed the Interagency Drainage Program. The program continued until 1979 when monitoring resumed as a separate activity under DWR's Agricultural Drainage Program.

The discovery in 1983 of migratory bird deaths and deformities linked to high selenium levels in drainage water at Kesterson Reservoir focused national attention on drainage of the San Luis Drain and drainage-related problems. This discovery resulted in an interagency drainage study.

In 1984, the San Joaquin Valley Drainage Program (SJVDP) was established to investigate and identify possible solutions to drainage and drainage-related problems. The SJVDP is a cooperative federal-State program established by the Secretary of the Interior and the Governor of California. Cooperating agencies are DWR, California Department of Fish and Game, USBR, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. The SJVDP developed a comprehensive study entitled *A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley*, also known as the "Rainbow Report" (September 1990). This report summarizes the results of subsurface agricultural drainage problems and presents a plan for managing drainage problems.

In 1991, federal and State agencies initiated the San Joaquin Valley Drainage Implementation Program to pick up where SJVDP left off. Four federal agencies (USBR, USFWS, USGS, and Natural Resources Conservation Service) and four State agencies (DFG, DWR, Department of Food and Agriculture, and SWRCB) signed a memorandum of understanding and released an implementation strategy in December 1991. They agreed to (1) work together and identify specific tasks associated with responsible parties, (2) seek needed funding and authority, and (3) set schedules for implementing all components of the SJVDP 1990 Plan.

The MOU and all the agencies involved recognize that the success of the program depends upon local districts and irrigators to carry out effective drainage management measures. Because drainage is a regional problem, federal and State agencies will continue to coordinate efforts. The DWR drainage monitoring program is continuously being evaluated and modified to meet the needs of the implementation strategy.

THE DRAINAGE PROBLEM

The San Joaquin Valley, one of the world's most productive agricultural regions, has experienced mounting problems with the management and disposal of agricultural drainage water.

The drainage problem is an outgrowth of naturally saline soils and imported water, as well as the valley's distinctive geological makeup, which prevents effective natural drainage in certain areas. Soils on the western side of the valley are derived from the marine sediments that make up the Coast Range. These soils, high in salts and trace elements, are similar to those that occur in a marine environment. In addition, much of the valley is underlain by a shallow, clay layer that obstructs vertical movement of irrigation water. As salts and minerals from surface soils are leached into the groundwater, the water table rises to within a few feet of the surface and into the root zone. Unless this water is removed, crops growing in these soils eventually die.

In the late 1940s, farmers began installing subsurface drains in fields with drainage problems. By 1965, 330 miles of subsurface drains and 750 miles of open ditch drains were in operation in the valley delivering drainage water to evaporation ponds and other discharge sites. With this drainage network in operation, the main problem became how to manage and dispose of the salty drain water.

The original plan was to construct a master drain (the San Luis Drain) to collect the water and route it out of the valley into the Sacramento-San Joaquin River Delta. By 1973, an 87-mile-long section of the San Luis Drain was receiving irrigation runoff and discharging into Kesterson Reservoir. The plan was to extend the drain north to a discharge site in the Delta. Kesterson Reservoir was to regulate discharges going to the Delta and provide a wetland habitat. The San Luis Drain was never completed and drainage accumulated at Kesterson Reservoir. In 1982, federal studies reported high selenium levels in fish taken from Kesterson. In 1983, federal-State studies determined that the bioaccumulation of selenium was causing deformities in embryos of waterfowl nesting at the reservoir. In 1985, the U.S. Department of the Interior ordered a halt to drainage water discharges into the San Luis Drain and Kesterson Reservoir, even though irrigation water deliveries to west side agricultural lands continued.

Today, the future of the master drain remains in doubt. Practices of disposing and managing drainage water are being scrutinized for their impacts on the environment. Management practices such as source control, drainage reuse, groundwater management, integrated on-farm drainage management, and others identified in the "Rainbow Report" are being implemented. Monitoring of shallow groundwater and agricultural drainage water is an integral activity to determine the effectiveness of these management practices.

DRAINAGE PROBLEM AREAS

The San Joaquin Valley is a rich agricultural region that encompasses large areas with high water tables. Irrigation practices, cropping patterns, seepage from unlined ditches or ponds, soil type, geology, and other factors influence the elevations of these water tables. Since the importation of water for irrigation, inadequate drainage and accumulating salts have been persistent problems in parts of the valley. The poor natural drainage conditions, coupled with rising groundwater levels and increasing soil salinity, have meant that various soils could no longer produce crops, and some farms within the problem area have been abandoned.

In this report "present problem area" is defined as a location where the water table is within 5 feet of the ground surface at any time during the year. A "potential problem area" indicates the water table is between 5 and 20 feet below the ground surface. Present and potential drainage problem areas are established by planimetering within specific intervals from DWR's annual "Present and Potential Drainage Problem Area" map (Plate 1).

Beginning with the 1991 map, study area boundaries were drawn and a standard method of data collection was established. Within the boundaries a network of monitoring wells interpret the water levels to establish acreage areas of the particular depth-to-water intervals. Plate 1 displays an overview of the respective depth-to-water intervals, as well as the boundaries of study for Grasslands, Westlands, Tulare, and Kern Sub basins. Table 1, Acreages of Present and Potential Drainage Problems, lists the acreage of drainage problems within the study for the years 1991 through 2000.

In preparing Plate 1, DWR did not take into account items such as existing drainage systems, wildlife refuges, urban areas, pasture land, native vegetation, data-poor areas, and the outer boundary. This report provides information on the extent of drainage conditions; therefore, other factors must be considered when making projections about areas that will require drainage systems in the future.

TABLE 1
ACREAGES OF PRESENT AND POTENTIAL DRAINAGE PROBLEMS
1991 through 2000

Depth to Groundwater	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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Grasslands Subbasin

0 to 5 ft	114,000	136,000	147,000	146,000	166,000	164,000	156,000	235,000	182,000	130,000
5 to 10 ft	184,000	150,000	131,000	128,000	144,000	153,000	186,000	117,000	150,000	165,000
10 to 15 ft	72,000	77,000	99,000	86,000	64,000	59,000	44,000	39,000	59,000	60,000
15 to 20 ft	42,000	46,000	33,000	51,000	35,000	33,000	22,000	7,000	5,000	17,000
TOTAL	412,000	409,000	410,000	411,000	409,000	409,000	408,000	398,000	396,000	372,000

Kern Subbasin

0 to 5 ft	40,000	34,000	24,000	10,000	32,000	50,000	58,000	84,000	77,000	39,000
5 to 10 ft	121,000	172,000	126,000	148,000	173,000	163,000	182,000	195,000	155,000	176,000
10 to 15 ft	152,000	84,000	162,000	137,000	115,000	82,000	78,000	77,000	96,000	87,000
15 to 20 ft	15,000	40,000	17,000	32,000	8,000	31,000	8,000	0	5,000	11,000
TOTAL	328,000	330,000	329,000	327,000	328,000	326,000	326,000	356,000	333,000	313,000

Tulare Subbasin

0 to 5 ft	119,000	189,000	199,000	131,000	195,000	219,000	307,000	264,000	233,000	113,000
5 to 10 ft	244,000	121,000	135,000	212,000	157,000	104,000	65,000	20,000	107,000	178,000
10 to 15 ft	2,000	54,000	30,000	23,000	11,000	17,000	6,000	0	0	0
15 to 20 ft	0	1,000	0	0	0	0	200	0	0	0
TOTAL	365,000	365,000	364,000	366,000	363,000	340,000	378,200	284,000	340,000	291,000

Westlands Subbasin

0 to 5 ft	38,000	110,000	75,000	34,000	126,000	104,000	228,000	278,000	146,000	146,000
5 to 10 ft	201,000	160,000	172,000	194,000	150,000	205,000	90,000	94,000	180,000	178,000
10 to 15 ft	85,000	69,000	87,000	96,000	65,000	58,000	49,000	20,000	49,000	46,000
15 to 20 ft	85,000	73,000	77,000	85,000	68,000	41,000	41,000	0	32,000	15,000
TOTAL	409,000	412,000	411,000	409,000	409,000	408,000	408,000	392,000	407,000	385,000

TOTALS

0 to 5 ft	311,000	469,000	445,000	321,000	519,000	537,000	749,000	861,000	638,000	428,000
5 to 10 ft	750,000	603,000	564,000	682,000	624,000	625,000	523,000	426,000	592,000	697,000
10 to 15 ft	311,000	284,000	378,000	342,000	255,000	216,000	177,000	136,000	204,000	193,000
15 to 20 ft	142,000	160,000	127,000	168,000	111,000	105,000	71,200	7,000	42,000	43,000
TOTAL AREA	1,514,000	1,516,000	1,514,000	1,513,000	1,509,000	1,483,000	1,520,200	1,430,000	1,476,000	1,361,000

Variations in total result from rounding of numbers.

2000 DRAINAGE MONITORING PROGRAM

DWR's San Joaquin Valley drainage-monitoring activities for 2000 consisted of collecting water samples from 28 subsurface and 2 surface drainage sumps. Figure 1 provides an overview of the sampling area locations with boundaries representing the Northern, Central, and Southern Areas.

The Northern Area, monitored by the USBR, consists of 1 surface and 9 subsurface drains. Due to budget constraints the Northern Area was last monitored in 1979; therefore, it is not included in the report. Efforts are currently being made to reestablish monitoring activities in the Northern Area. DWR monitors the Central and Southern Area stations listed in Table 2 and presented in Figures 2 and 3, respectively.

TABLE 2
DRAINAGE MONITORING STATIONS
2000

<u>Central Area</u>		<u>Southern Area</u>
BVS	6016	CCN 3550
BVS	8003	CNR 0801
CTL*	4504	COC 4126
DPS	1367	COC 5329
DPS	2535	ERR 7525
DPS*	3235	ERR 8429
DPS	3465	ERR 8641
DPS	4616	GSY 0855
FBH	2016	HCH 7439
FBH	8061	LME 7569
HMH	7516	LNW 5454
		LNW 5467
		LNW 6459
		LNW 6467
		SFD 2727
		STC 5436
		VGD 3906
		VGD 4406
		VGD 5412

*Surface drain

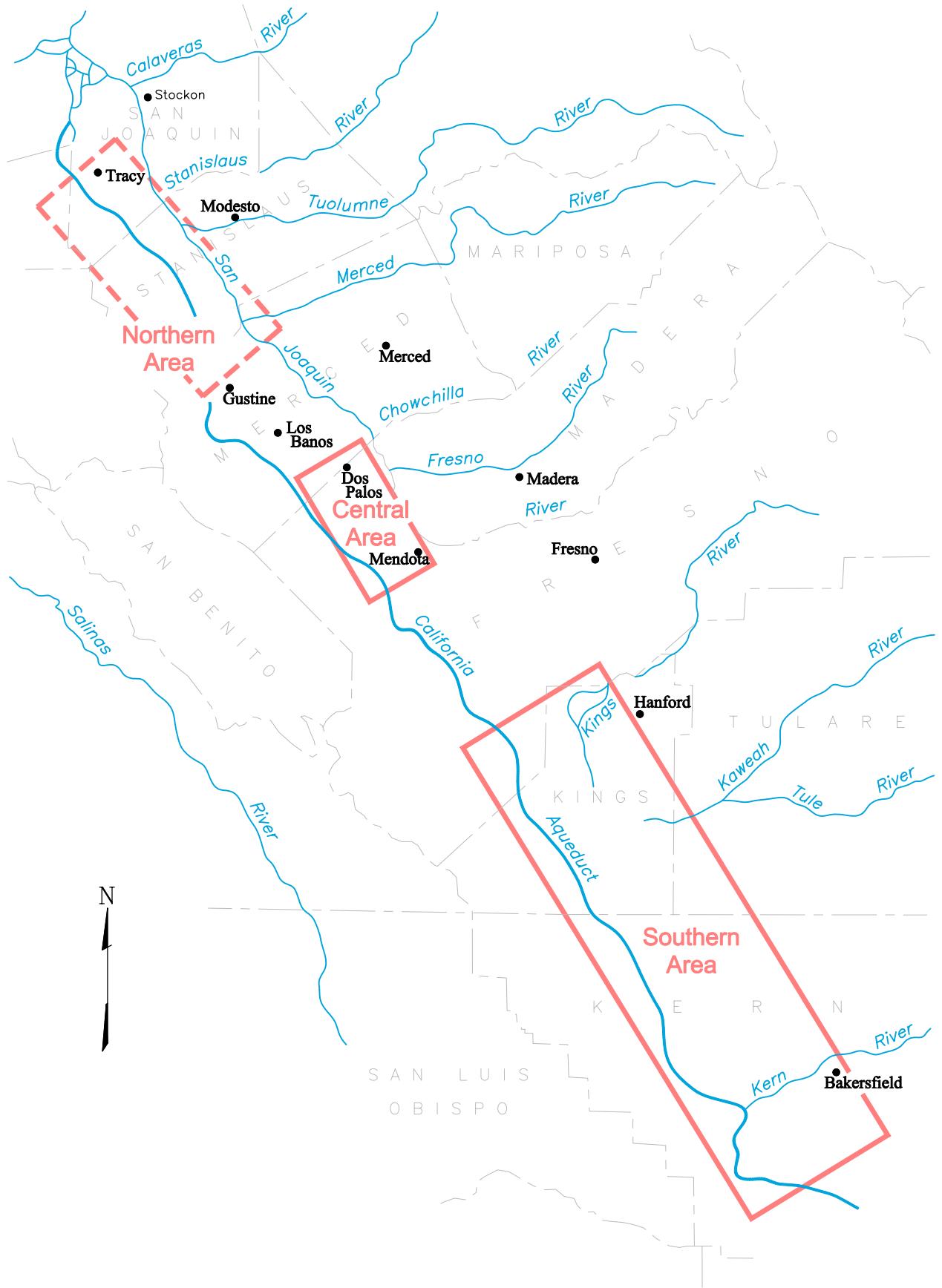


Figure 1. Overview of Sampling Area Locations

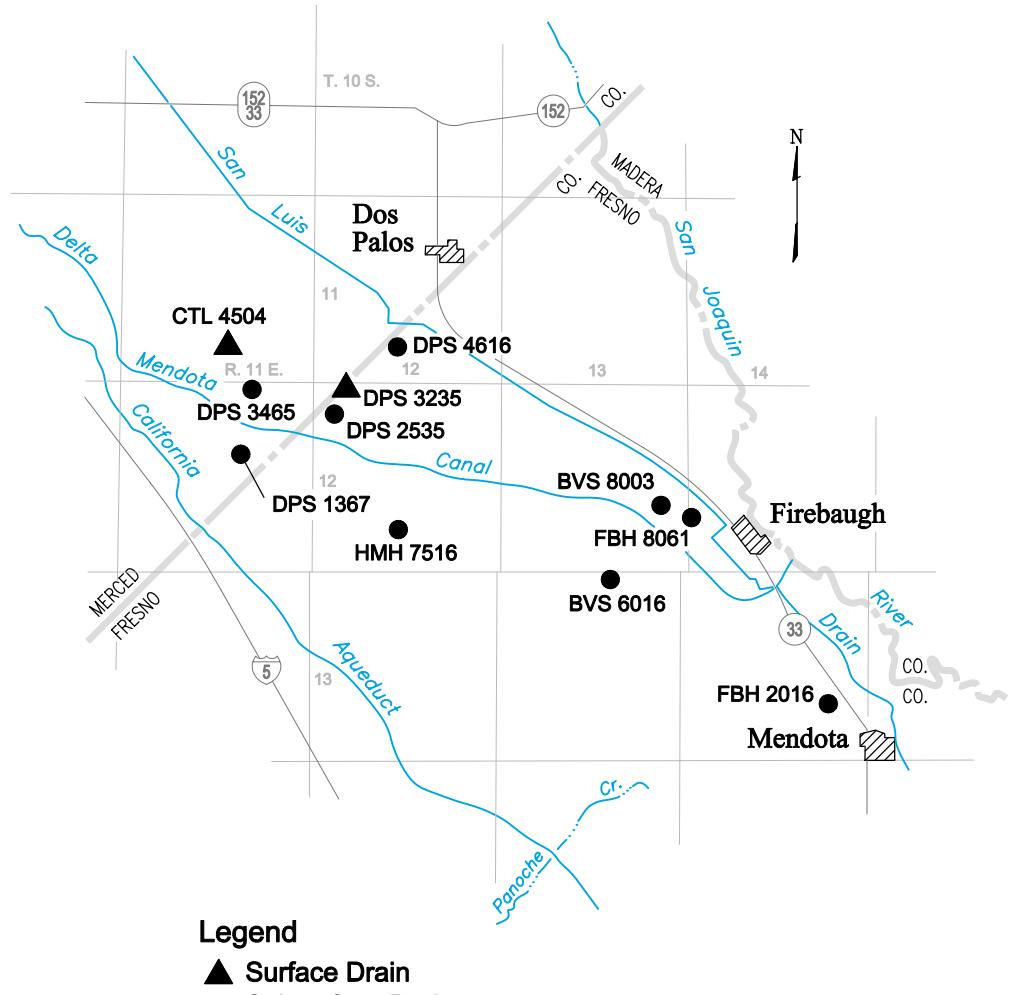
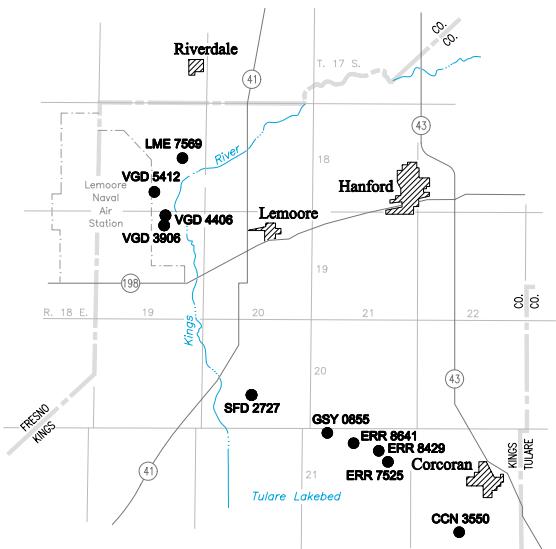
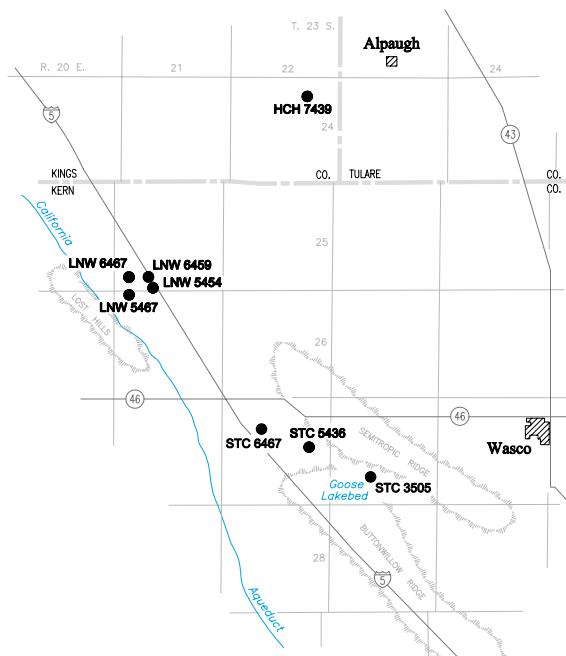


Figure 2. Central Area Drain Locations



Lemoore/Corcoran Stations



Lost Hills/Semotropic Stations

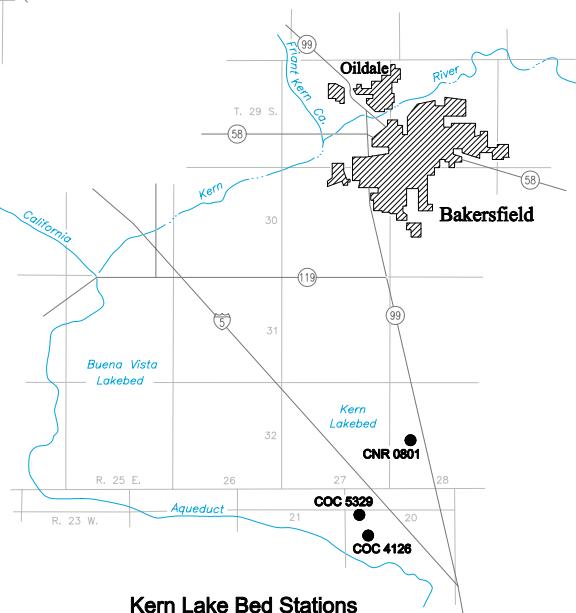


Figure 3. Southern Area Drain Locations

Flows

Drainage flow data are collected from sumps with functional flow meters. Many drains receive groundwater from areas outside the drainage pipe collector network. As a result, one drainage sump may act as a collector point for six or more systems. Depending on the soil surrounding the drain, one month's flow may consist of part of the previous month's irrigation; therefore, caution should be exercised in using the given results. Table 3 lists the 2000 subsurface drain flows in acre-feet.

TABLE 3
SUBSURFACE DRAIN FLOWS
2000
(acre feet)

Station	Area Tiled (acres)	Jan - Mar 11 9	Mar - May 9 9	May - July 9 11	July - Sept 11 12	Sept - Nov 12 6	Nov - Jan 2001 6 9
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Central Area

BVS 6016	640	7.0	18.9	107.0	77.2	-	-
BVS 8003	126	-	27.3	13.3	10.2	2.1	-
DPS 1367	125	70.0	40.3	67.6	25.5	26.5	28.9
DPS 2535	295	66.8	55.6	67.4	52.6	2.5	-
DPS 3465	160	11.8	12.0	-	-	22.1	-
DPS 4616	120	-	-	-	-	-	-
FBH 2016	80	-	37.3	14.0	9.2	-	-
FBH 8061	240	-	78.2	19.3	39.0	6.5	-
HMH 7516	320	-	-	-	-	-	-

Southern Area

CCN 3550	560	-	-	-	5.3	0.4	5.6
CNR 0801	68	-	-	-	-	-	-
COC 4126	120	-	-	-	-	-	-
COC 5329	300	-	-	-	-	-	-
ERR 7525	265	-	-	-	-	-	-
ERR 8429	-	67.2	91.7	80.1	90.8	57.9	40.3
ERR 8641	258	21.4	24.5	26.8	24.5	17.7	15.6
GSY 0855	55	-	-	-	-	11.4	0.05
HCH 7439	-	-	-	52.0	12.4	8.7	9.0
LME 7569	-	-	-	-	-	-	-
LNW 5454	1,833	-	-	61.0	88.8	2.8	7.8
LNW 5467	1,770	-	-	-	-	-	-
LNW 6459	581	-	61.0	-	44.4	0.4	-
LNW 6467	1,420	35.9	86.9	80.8	72.2	22.3	21.7
SFD 2727	120	-	-	-	-	-	-
STC 5436	153	-	-	-	-	-	-
VGD 3906	870	-	-	-	-	-	-
VGD 4406	310	-	-	-	-	-	-
VGD 5412	275	-	-	-	-	-	-

- Denotes insufficient data or no reading.

Mineral Constituent Concentrations

The report investigates individual minerals and associated salts from a cation perspective. Historical data have provided the opportunity to analyze sodium, calcium, and magnesium for trends. Also, since cations are featured in the report, charts are provided showing the salt composition of the water for a particular area or surface drain.

Two averages are presented in the report: arithmetic average and geometric mean. The arithmetic average is the average of all data obtained for the given period, whereas the geometric mean (extensively used by regulatory agencies) gives an average of central tendency that is less influenced by spiked values in the data set.

The Southern Area is divided into three sub-areas because evaluation of the Southern Area as a congregate distorts the results of the individual sub-areas. The stations in the sub-areas were determined by their proximity to one another along with the idea that geologic attributes are similar because of proximity. The sub-areas are named Lemoore-Corcoran, Lost Hills-Semitropic, and Kern Lakebed.

All natural waters, including drainage water, contain a matrix of dissolved mineral substances that can be divided into two categories: cations and anions. Cations are positively charged ions and are usually metals. Anions are negatively charged ions and are acids, or acid radicals. Common cations monitored are sodium, calcium, magnesium, and potassium. Common anions monitored are bicarbonate, carbonate, sulfate, chloride, nitrate, and boron. Both cations and anions combine to form salts and should be in balance for a given water analysis. The more prevalent salts in the drainage water matrix are sodium sulfate, sodium chloride, calcium carbonate, calcium sulfate, calcium chloride, magnesium sulfate, and magnesium chloride, while potassium chloride, potassium sulfate and others make up the balance. In addition, cations are used to calculate the water quality indices of the sodium adsorption ratio (SAR) and total hardness, as well as determine the physical and chemical properties of soil.

The salinity in water is measured as either total dissolved solids (TDS) in milligrams per liter (mg/L) or electrical conductivity (EC) in microsiemens per centimeter ($\mu\text{S}/\text{cm}$). In practice, EC is a measure of the ability to conduct an electrical current through a given solution and is used to indicate the total salt content or TDS for a given water at a specific site. The more salts in the water, the better conductor it becomes. The strength of the electrical current is dependent upon the temperature of the solution and type and concentration of ion within the solution. The standard practice, as used in this report, is to adjust EC measurements to 75°F (25°C). TDS and EC, in conjunction with other parameters such as SAR and total hardness, are used to determine the suitability of water for agriculture.

The SAR was established to determine water permeability concerns. The sodium in a high SAR value water replaces the more beneficial calcium and magnesium ions in the soil. This exchange alters the soil structure causing the soil to slake, resulting in a loss of porosity, and reducing the infiltration rate of the applied water through the soil. In general, irrigation waters having SAR values less than 3 are low risk. Some salt tolerant crops may have SAR values as high as 16. Considerable care is recommended for values greater than 6 when reusing agricultural drainage water for irrigation purposes.

Total hardness is a water quality parameter used to determine the suitability of water for agriculture. Problems arise with the formation of scale inside pipelines and irrigation equipment with the use of water high in hardness.

Hardness refers to the capacity of water to precipitate soap and is defined as the sum of calcium and magnesium concentrations. Even though other polyvalent cations (iron, manganese, copper, lead, zinc, and other trace elements) contribute to hardness, they are usually of minute quantities and are neglected.

A summary of the mineral constituents analyzed along with total hardness and SAR values for the stated area, sub-area or surface drain are provided in Table 4. A complete listing of mineral results for each station is given in Appendixes A and B.

TABLE 4
SUMMARY OF MINERALS DETECTED
2000
(milligrams per Liter)

Element	Southern Area				Central Area			
	Minimum	Maximum	Arithmetic Average	Geometric Mean	Minimum	Maximum	Arithmetic Average	Geometric Mean
<i>Lemoore-Corcoran Stations</i>								
Boron	0.1	38	11	4.6	2.5	39	11	9.4
Calcium	44	410	244	207	221	634	413	400
Hardness (as CaCO ₃)	209	7,450	1,922	1,375	770	2,292	1,659	1,603
Magnesium	23	816	286	189	53	291	153	140
Nitrate	1.9	86	40	30	5.6	228	109	82
Potassium	1.7	22	7.5	6.2	2.1	8.0	4.3	4.0
SAR	3.3	57	27	22	0.1	17	9.6	7.9
Sodium	122	8,420	2,761	1,878	193	1,710	944	840
TDS	739	30,860	11,147	7,769	1,606	8,120	5,124	4,797
Lab EC (μS/cm)	1,030	29,900	12,173	9,247	2,010	9,910	6,293	5,969
<i>Lost Hills-Semitropic Stations</i>								
Boron	3.2	50	23	17	0.2	1.1	0.5	0.4
Calcium	63	614	365	280	20	53	31	29
Hardness (as CaCO ₃)	330	2,946	1,590	1,271	98	215	139	134
Magnesium	42	343	165	134	11	20	15	15
Nitrate	1.4	280	133	63	1.2	5.9	3.5	3.1
Potassium	1.8	11	5.3	4.8	1.8	3.2	2.4	2.4
SAR	19	97	42	38	1.9	2.7	2.4	2.4
Sodium	909	9,210	3,661	3,118	44	84	65	64
TDS	2,900	30,000	13,094	11,209	231	550	365	351
Lab EC (μS/cm)	4,290	36,500	16,379	14,374	406	926	619	598
<i>Kern Lakebed Stations</i>								
Boron	2.4	25	10	7.0	7.5	8.6	8.1	8.0
Calcium	336	594	511	501	274	370	337	336
Hardness (as CaCO ₃)	1,785	2,260	2,089	2,085	994	1,340	1,225	1,219
Magnesium	123	307	197	189	75	101	93	92
Nitrate	165	418	276	268	80	159	124	121
Potassium	2.5	61	18	9.2	2.5	5.0	4.4	4.2
SAR	4.9	20	11	10	7.7	8.8	8.0	8.0
Sodium	505	2,130	1,168	1,034	558	737	647	645
TDS	4,254	9,472	6,526	6,279	2,990	3,840	3,574	3,562
Lab EC (μS/cm)	4,820	10,580	7,354	7,060	4,020	4,970	4,722	4,709

No surface drains within the Southern Area.

Salt composition charts that show the percentage of salt type for the area, sub-area, and surface drain are provided in Figures 4 through 9. The percentages used to generate the charts were determined from the geometric mean values in Table 4. A comparison of the drainage water salt composition for the years 1986 and 2000 are given in Table 5 and show relatively little change within the subsurface drains.

To compare the analyses with one another, the two surface drains are presented separately. Although the constituent concentrations for station DPS 3235 are 10 times that of station DPS 4505, their compositions are relatively identical for 2000. Interestingly, station DPS 3235's calcium salts decreased 10% from 1986, while the sodium salts increased 7.8%.

TABLE 5
DRAINAGE WATER SALT COMPOSITIONS
1986 and 2000
(value in milliequivalents per Liter)

Element	Southern Area				Central Area			
	1986		2000		1986		2000	
	value	%	value	%	value	%	value	%
<i>Lemoore-Corcoran Stations</i>								
Calcium	12.6	7.6	10.3	9.6	19.4	26.9	19.9	29.3
Magnesium	31.9	19.3	15.6	14.4	13.0	18.0	11.5	16.9
Potassium	0.17	0.10	0.16	0.10	0.08	0.10	0.10	0.20
Sodium	120.2	72.9	81.6	75.8	39.6	55.0	36.5	53.6
<i>Lost Hills-Semitropic Stations</i>								
Calcium	12.9	7.5	14.0	8.6	5.3	28.2	1.5	26.4
Magnesium	10.3	5.9	11.0	6.8	3.2	17.1	1.2	21.9
Potassium	1.71	1.00	1.62	1.00	0.11	0.60	0.06	1.10
Sodium	148.1	85.6	135.6	83.6	10.2	54.1	2.8	50.5
<i>Kern Lakebed Stations</i>								
Calcium	22.2	24.6	25.0	29.1	16.7	41.9	16.7	31.9
Magnesium	16.8	18.6	15.6	18.2	4.9	12.2	7.6	14.5
Potassium	0.32	0.40	0.23	0.30	0.12	0.30	0.11	0.20
Sodium	51.1	56.5	45.0	52.4	18.2	45.6	28.0	53.4
<i>Surface Drain CTL 4504</i>								
<i>Surface Drain DPS 3235</i>								

FIGURE 4
LEMOORE-CORCORAN
SALT COMPOSITION PERCENTAGES
2000

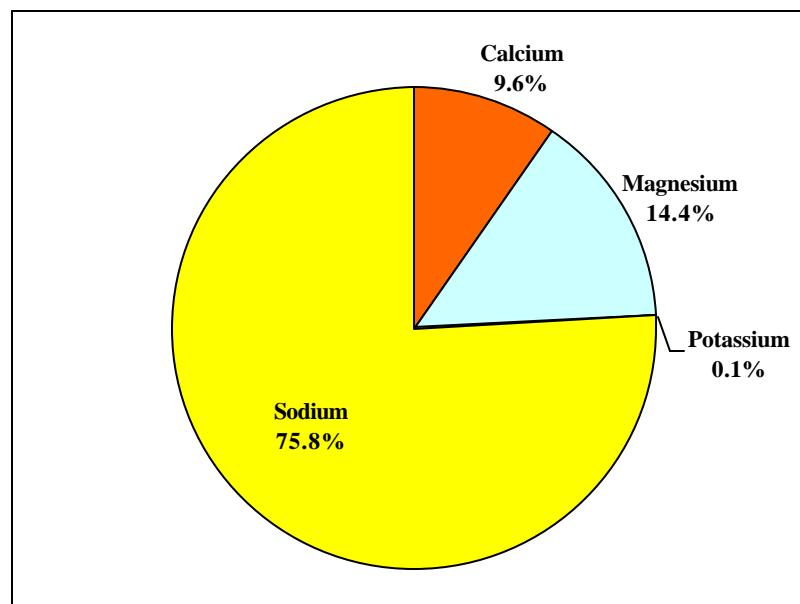


FIGURE 5
LOST HILLS-SEMITROPIC
SALT COMPOSITION PERCENTAGES
2000

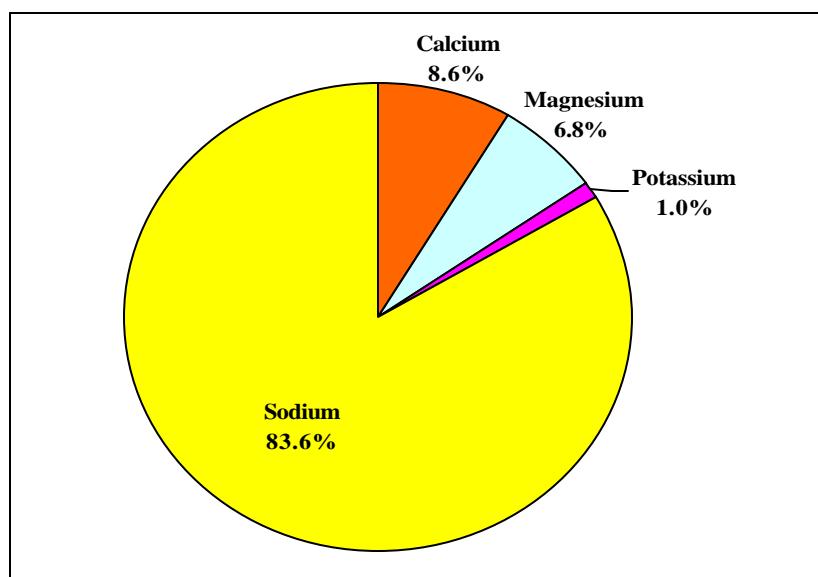


FIGURE 6
KERN LAKEBED
SALT COMPOSITION PERCENTAGES
2000

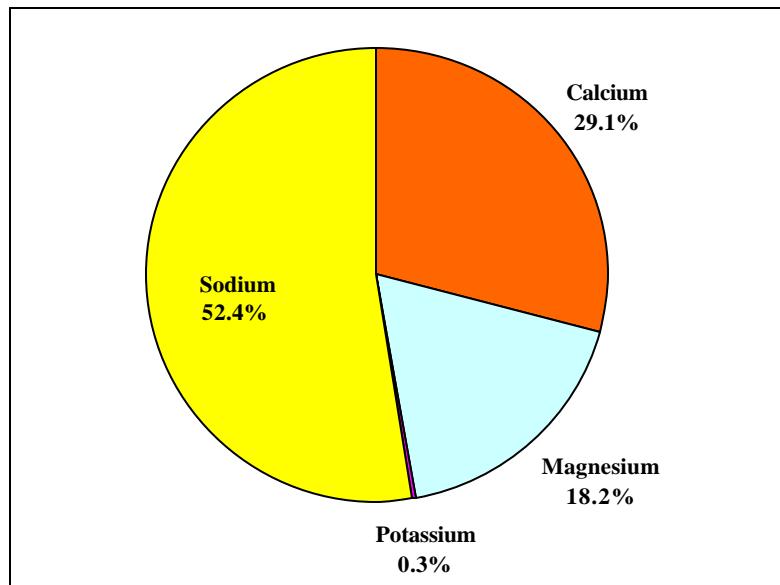


FIGURE 7
CENTRAL SUBSURFACE DRAIN
SALT COMPOSITION PERCENTAGES
2000

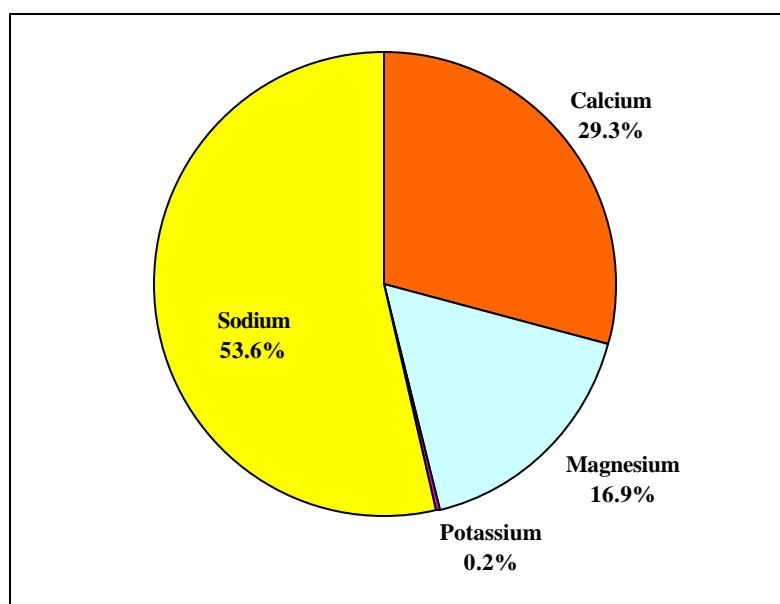


FIGURE 8
SURFACE DRAIN CTL 4504
SALT COMPOSITION PERCENTAGES
2000

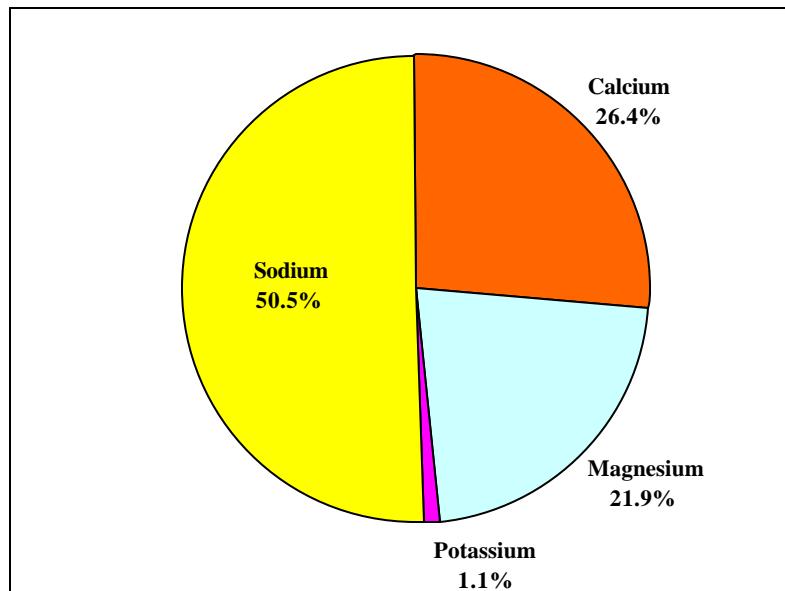
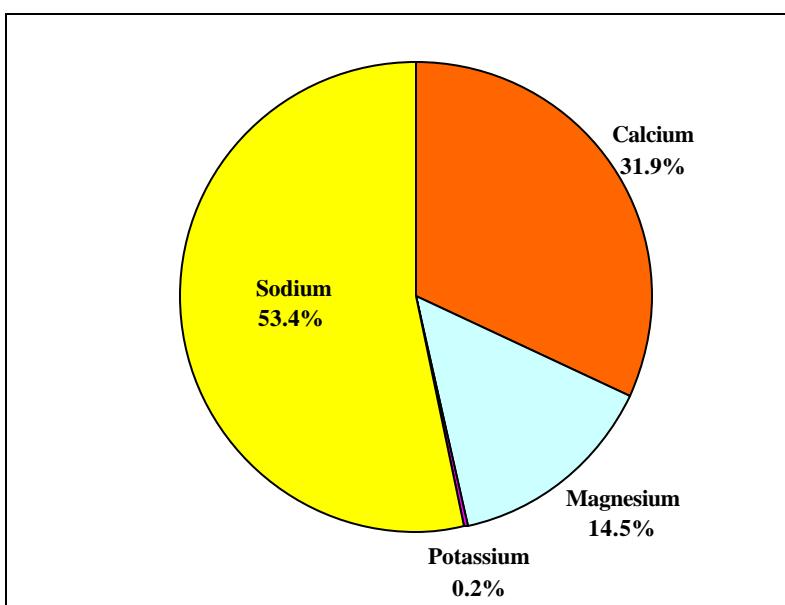


FIGURE 9
SURFACE DRAIN DPS 3235
SALT COMPOSITION PERCENTAGES
2000



Calcium, an essential element for plant growth, reduces the detrimental effects of sodium salts in water. Although hardness as calcium carbonate (CaCO_3) above 300 mg/L has a tendency to scale, excessive levels of calcium are rarely harmful to plant growth and often desirable in irrigation water. For example, as well as replacing the sodium on soil particles, calcium improves a soil's physical properties by allowing water to penetrate readily and the sodium to be leached below the root zone. In agricultural practice, calcium, the primary component of a soil amendment (gypsum) is used to improve soil permeability. Calcium values for area subsurface drains are given in Table 6.

TABLE 6
CALCIUM IN SUBSURFACE DRAINS
1986 through 2000
(milligrams per Liter)

<u>Arithmetic Average</u> <u>Geometric Mean</u>															2000			
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000	Min	Max			
<u>Central Area</u>																		
398	379	392	410	411	418	422	429	422	411	423	458	407	413	221	634			
389	367	378	393	400	402	406	417	408	396	410	447	392	400					
<u>Southern Area</u>																		
<i>Lemoore-Corcoran</i>																		
279	268	270	292	302	289	278	307	273	237	263	266	274	244	44	410			
252	239	236	253	267	250	233	254	227	192	227	233	234	207					
<i>Lost Hills-Semitropic</i>																		
351	390	331	330	331	367	365	364	349	373	408	505	396	365	63	614			
259	280	212	217	215	238	217	233	203	245	291	451	328	280					
<i>Kern Lakebed</i>																		
457	428	457	463	448	483	456	393	442	462	514	496	485	511	336	594			
445	408	443	444	423	454	392	336	390	442	501	486	475	501					

No data collected in 1995.

Historical calcium average and geometric mean data (Table 6) for the Central and Southern Area subsurface drains are displayed in Figures 10 through 13. The data are further illustrated through linear regression to demonstrate a trend line increase or decrease from 1986 through 2000.

Calcium trends in subsurface drains illustrate an increase for the years 1986 through 2000. The Central Area calcium trends (Figure 10) indicate an increase of 8% for both average and geometric mean. In the Southern Area, Lemoore-Corcoran stations (Figure 11) show a trend decline of 10% and 15% in the average and geometric mean, respectively; Lost Hills-Semitropic stations (Figure 12) show a significant rise of 21% and 50% in the average and geometric mean, respectively; and Kern Lakebed stations (Figure 13) indicate a rise of 11% and 15% in the average and geometric mean, respectively.

FIGURE 10
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 CALCIUM IN CENTRAL SUBSURFACE DRAINS
 1986 through 2000

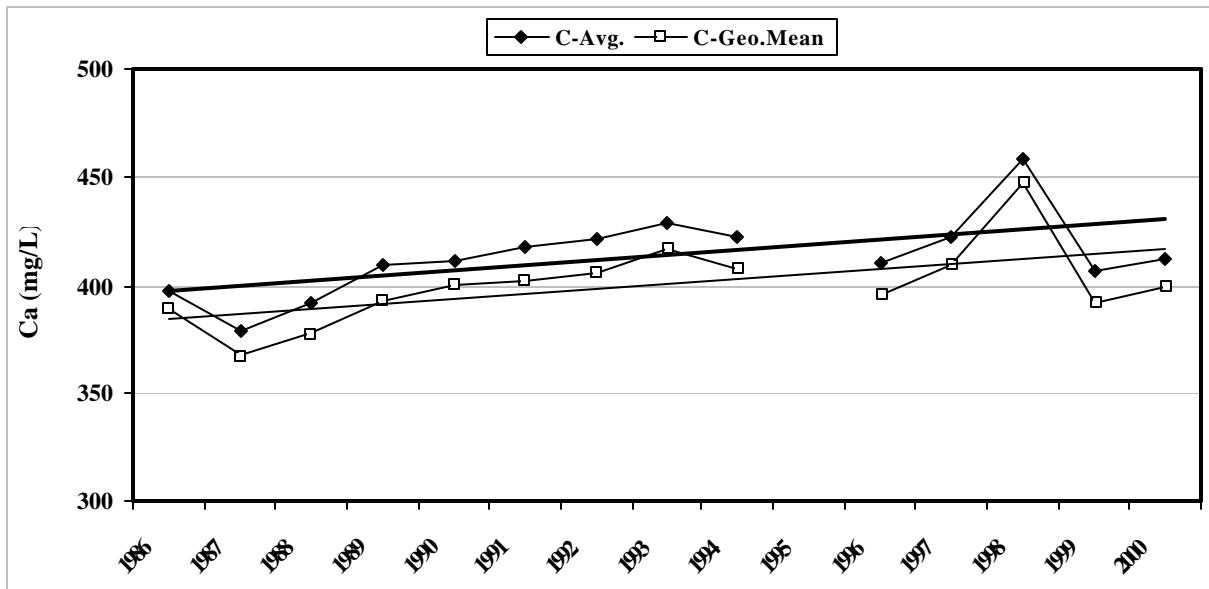


FIGURE 11
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 CALCIUM IN LEMOORE-CORCORAN STATIONS
 1986 through 2000

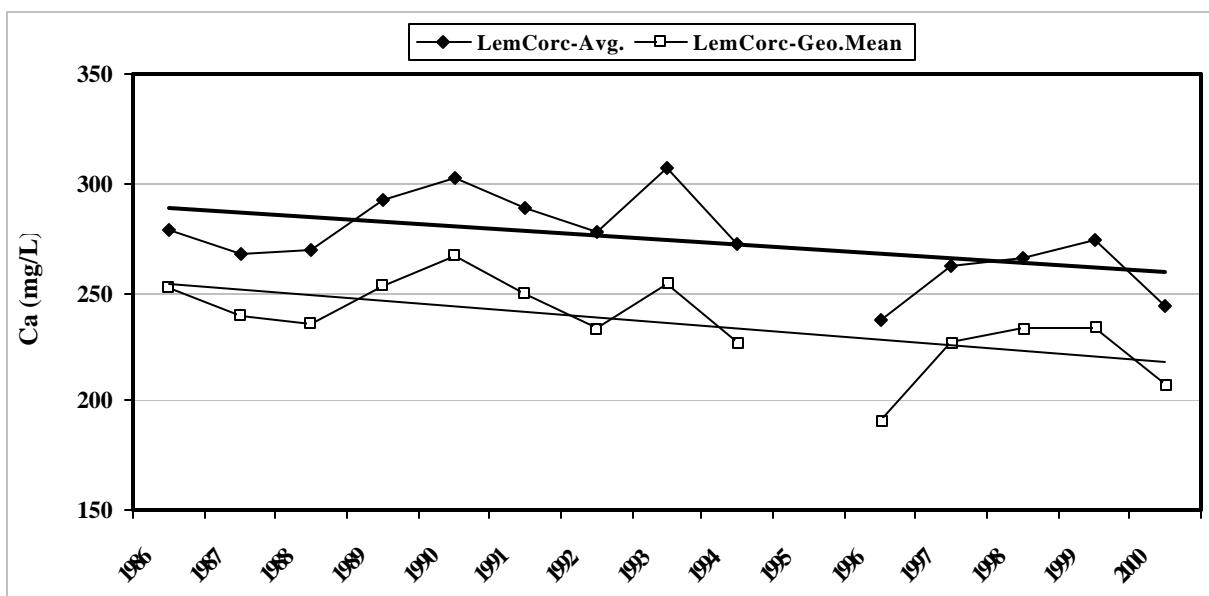


FIGURE 12
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 CALCIUM IN LOST HILLS-SEMITROPIC STATIONS
 1986 through 2000

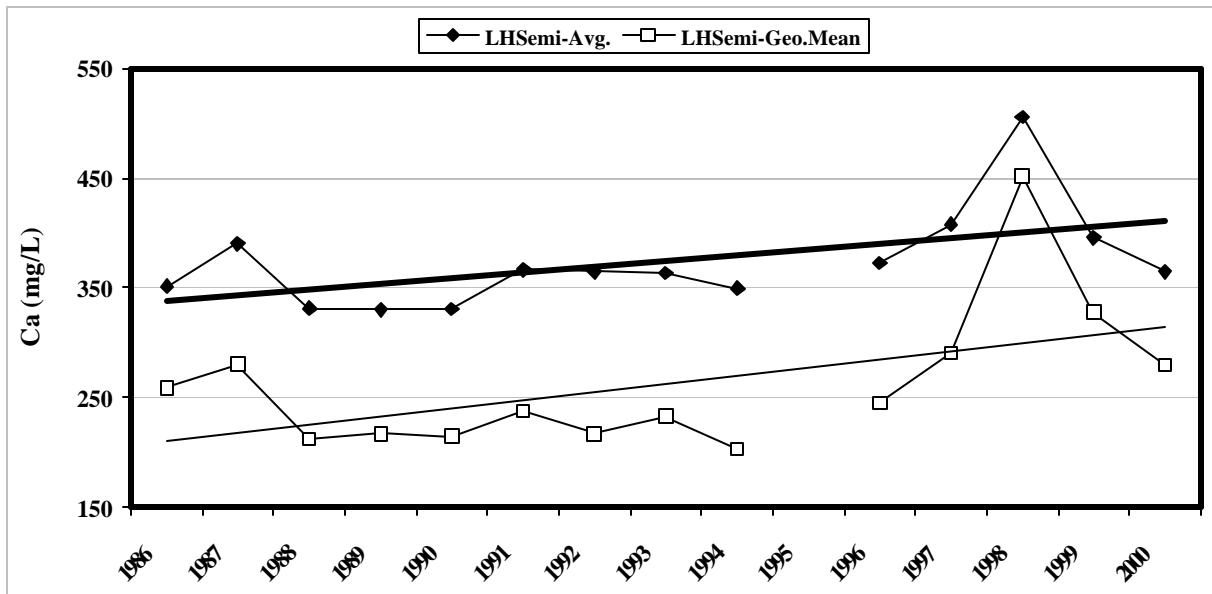
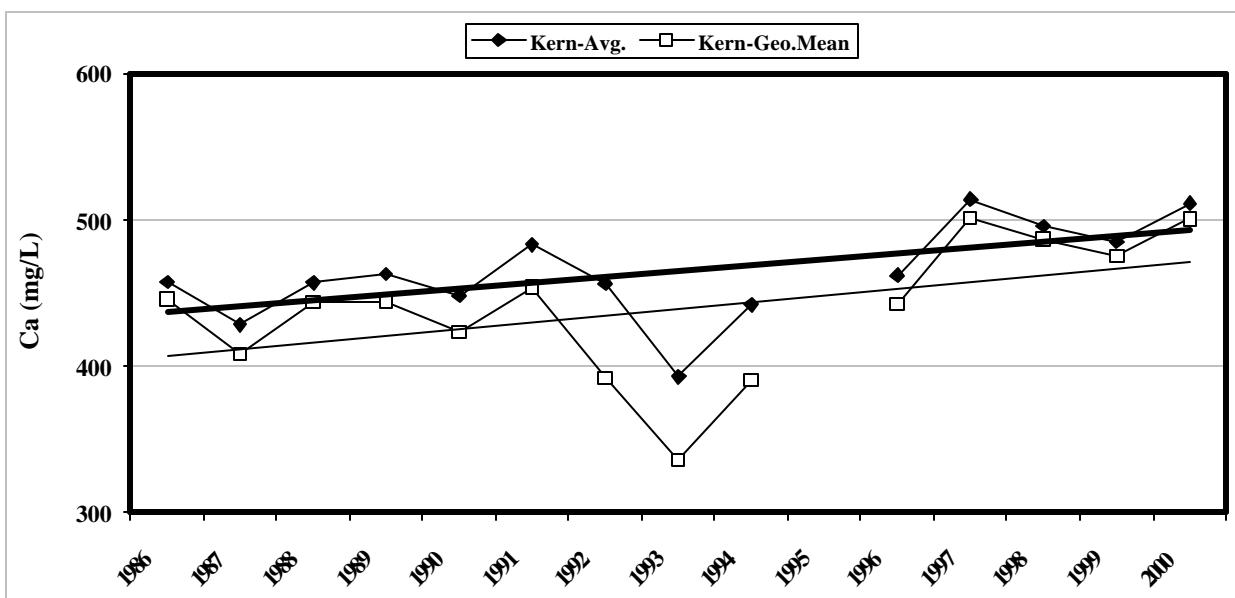


FIGURE 13
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 CALCIUM IN KERN LAKEBED STATIONS
 1986 through 2000



Magnesium is an essential molecule that activates enzymes in the growth processes of the plant and is necessary to maintain green leaves. Greater amounts are often found in the subsoil than in upper parts of the soil profile. As a result, young plants are more vulnerable until their root systems penetrate the subsoil. As with calcium, magnesium deficiency is more prevalent on hardpan soils that are highly leached and weathered. Magnesium averages from 1986 through 2000 are listed in Table 7.

TABLE 7
MAGNESIUM IN SUBSURFACE DRAINS
1986 through 2000
(milligrams per Liter)

Arithmetic Average Geometric Mean														2000			
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000	Min	Max		
<u>Central Area</u>																	
175	206	189	179	176	196	180	176	188	171	166	174	166	153	53	291		
157	177	161	154	154	167	153	147	161	150	148	149	146	140				
<u>Southern Area</u>																	
<i>Lemoore-Corcoran</i>																	
523	608	503	480	503	442	502	455	467	273	306	305	314	286	23	816		
387	399	225	312	330	277	307	292	300	167	221	219	214	189				
<i>Lost Hills-Semitropic</i>																	
231	235	187	154	162	198	206	194	188	174	186	217	176	165	42	343		
125	147	100	79	77	107	99	103	97	79	105	185	145	134				
<i>Kern Lakebed</i>																	
244	270	314	256	221	176	154	135	149	193	202	222	222	197	123	307		
204	213	270	229	196	172	141	131	146	187	189	208	208	189				

No data collected in 1995.

The overall trends for magnesium in subsurface drains declined from 1986 through 2000. The Central Area average and geometric mean (Figure 14) declined 16% and 12%, respectively. Averages for the Southern Area include: Lemoore-Corcoran stations (Figure 15) dropped 52% and 47% in the average and geometric mean, respectively; Lost Hills-Semitropic stations (Figure 16) declined 12% in the average and increased 30% in the geometric mean; Kern Lakebed stations (Figure 17) declined 27% and 12% in the average and geometric mean, respectively.

FIGURE 14
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 MAGNESIUM IN CENTRAL SUBSURFACE DRAINS
 1986 through 2000

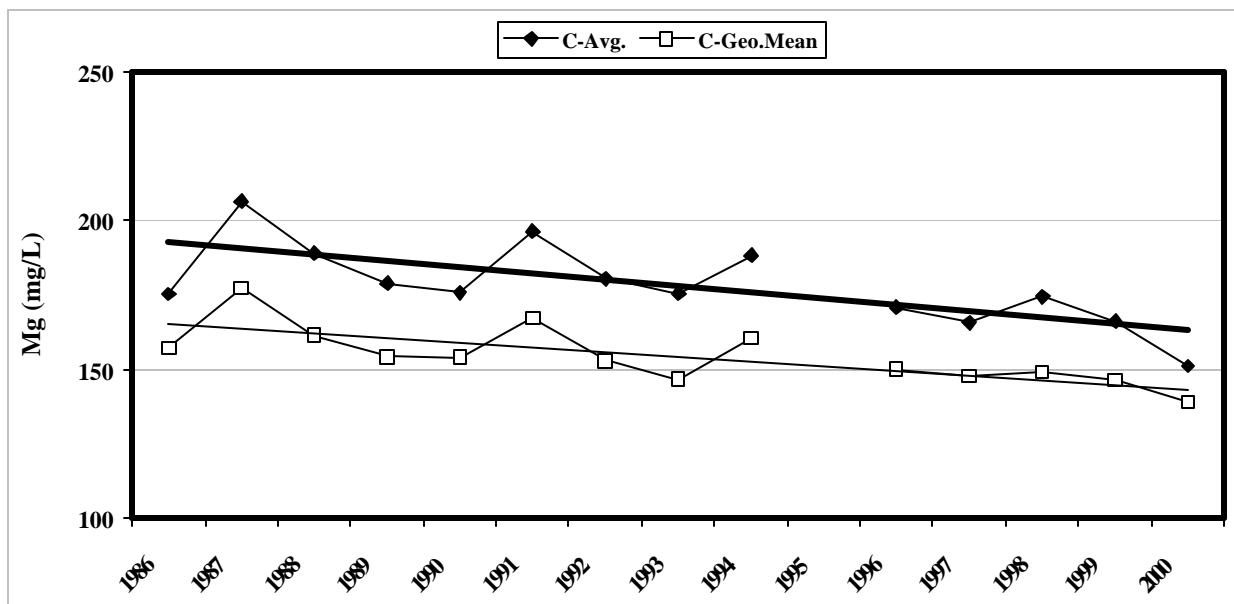


FIGURE 15
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 MAGNESIUM IN LEMOORE-CORCORAN STATIONS
 1986 through 2000

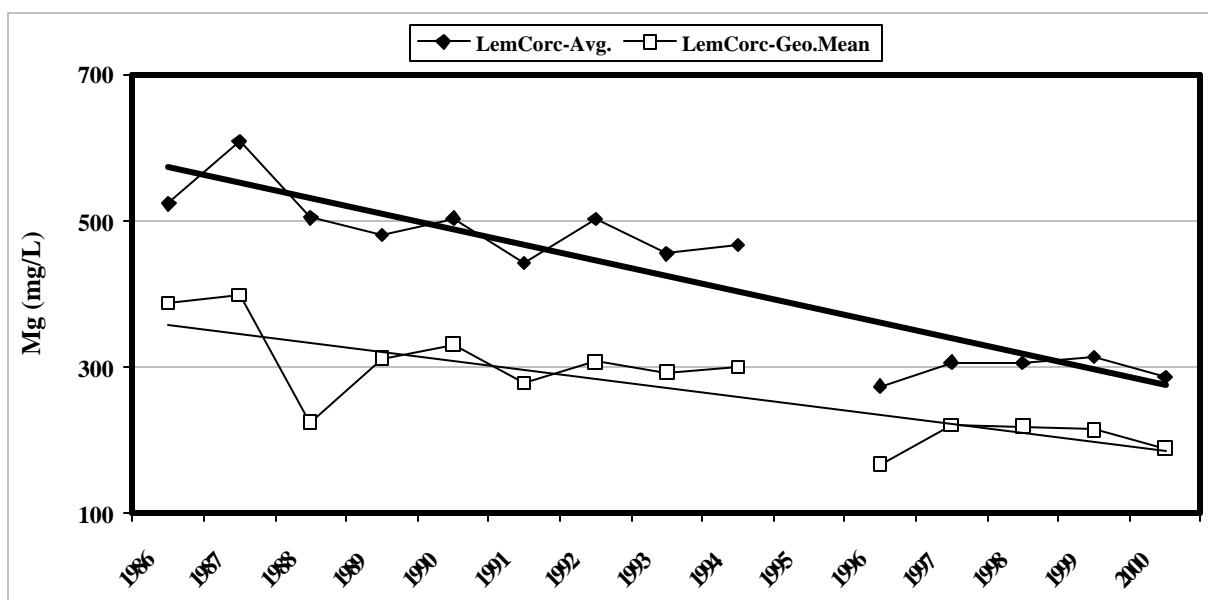


FIGURE 16
AVERAGE AND GEOMETRIC MEAN TREND LINES FOR MAGNESIUM IN LOST HILLS-SEMITROPIC STATIONS
1986 through 2000

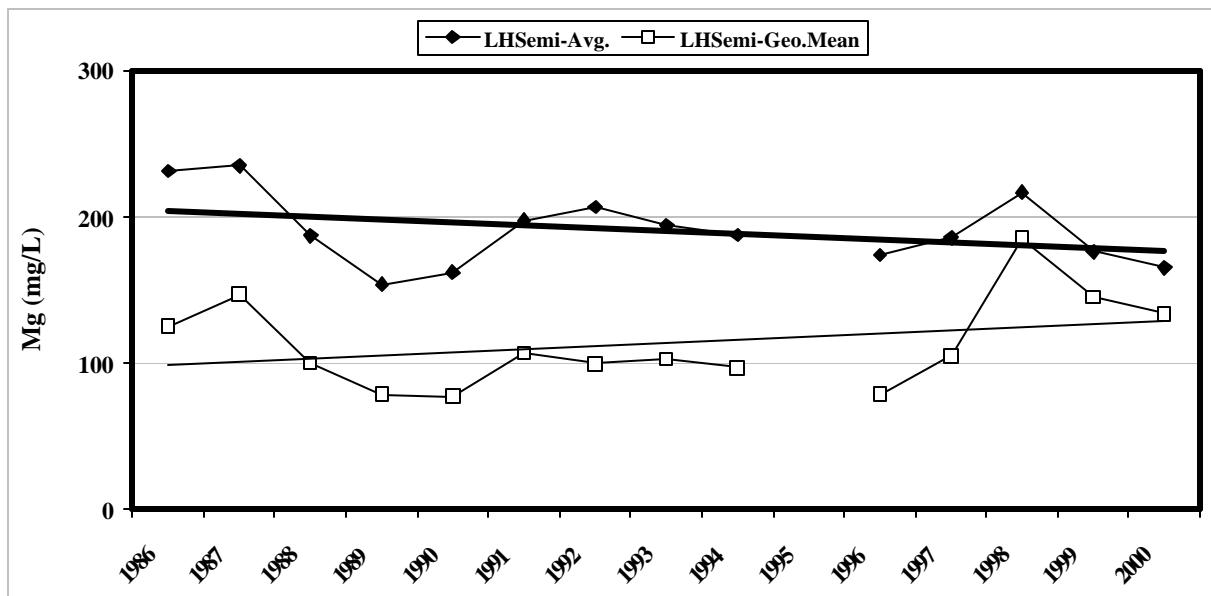
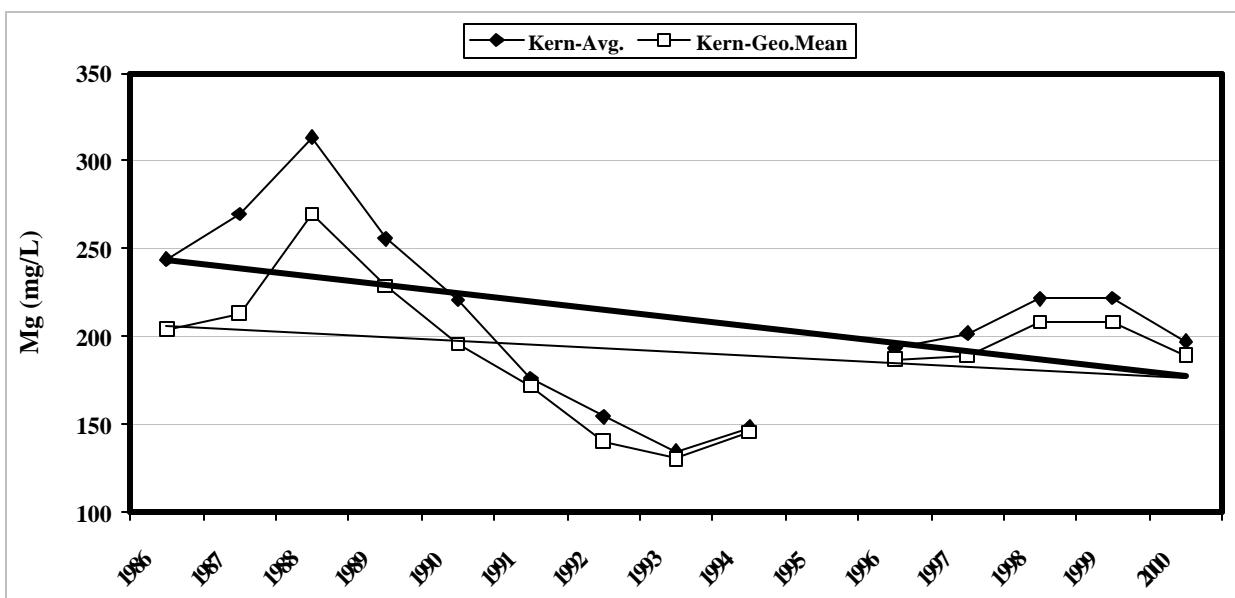


FIGURE 17
AVERAGE AND GEOMETRIC MEAN TREND LINES FOR MAGNESIUM IN KERN LAKEBED STATIONS
1986 through 2000



Sodium in water has negative effects on soil permeability and plant growth. Because of its large radius of hydration, sodium causes clay soils to disperse. When clay soils are dispersed, the soil pore size is reduced and permeability of water through the soil is greatly decreased. This loss in soil permeability increases salinity levels, which in turn decreases the available water and plant nutrients within the soil, thereby impeding the plant's ability to grow. In addition, areas with drainage water high in sodium will have a direct impact upon the water's reuse for irrigation of agricultural crops and potentially reduce the crop yield. Sodium averages from 1986 through 2000 are given in Table 8.

TABLE 8
SODIUM IN SUBSURFACE DRAINS
1986 through 2000
(milligrams per Liter)

Arithmetic Average														2000			
Geometric Mean																	
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000	Min	Max		
<u>Central Area</u>																	
1,047	1,225	1,071	1,048	1,061	1,128	1,013	1,119	1,096	1,033	1,048	1,184	1,032	944	193	1,710		
911	1,019	910	887	901	933	820	937	907	879	909	998	888	840				
<u>Southern Area</u>																	
<i>Lemoore-Corcoran</i>																	
3,911	4,807	3,590	3,844	4,155	4,028	4,023	4,315	4,135	2,689	2,956	2,917	3,210	2,761	122	8,420		
2,764	3,412	2,653	2,522	2,966	2,740	2,593	3,039	2,940	1,859	2,141	2,352	2,335	1,878				
<i>Lost Hills-Semotropic</i>																	
5,614	5,845	4,560	3,802	4,122	4,154	4,546	4,850	4,039	3,042	4,369	4,781	3,519	3,661	909	9,210		
3,406	3,832	2,545	2,171	2,255	2,425	2,522	2,732	2,412	1,989	3,146	4,226	3,141	3,118				
<i>Kern Lakebed</i>																	
1,880	2,360	2,653	2,397	2,012	1,037	899	835	879	979	1,193	1,505	1,485	1,168	505	2,130		
1,174	1,358	1,793	1,722	1,382	902	779	804	838	862	1,030	1,348	1,284	1,034				

Sodium trends in subsurface drains indicate a decline from 1986 through 2000. The Central Area averages (Figure 18) show a moderate decline of 6% and 5% in the average and geometric mean, respectively. Within the Southern Area, the Lemoore-Corcoran averages (Figure 19) declined 34% and 31% in the average and geometric mean, respectively. The Lost Hills-Semotropic averages (Figure 20) declined 28% in the average and increased 11% in the geometric mean. The Kern Lakebed averages (Figure 21) show a significant drop of 55% and 27% in the average and geometric mean, respectively.

FIGURE 18
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 SODIUM IN CENTRAL SUBSURFACE DRAINS
 1986 through 2000

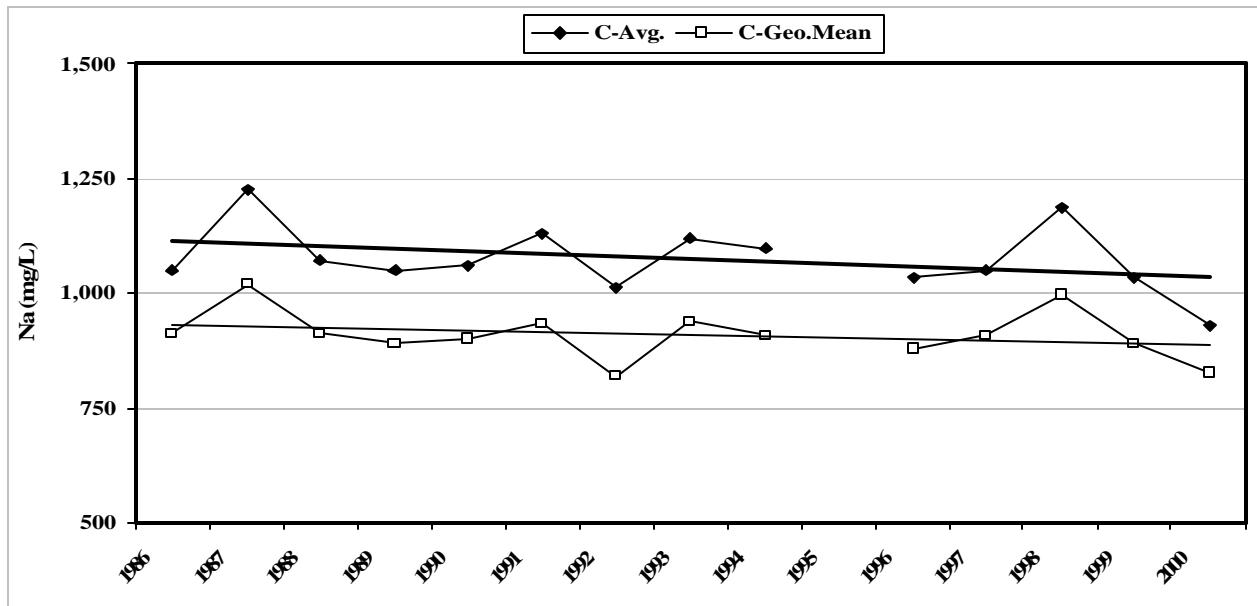


FIGURE 19
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 SODIUM IN LEMOORE-CORCORAN STATIONS
 1986 through 2000

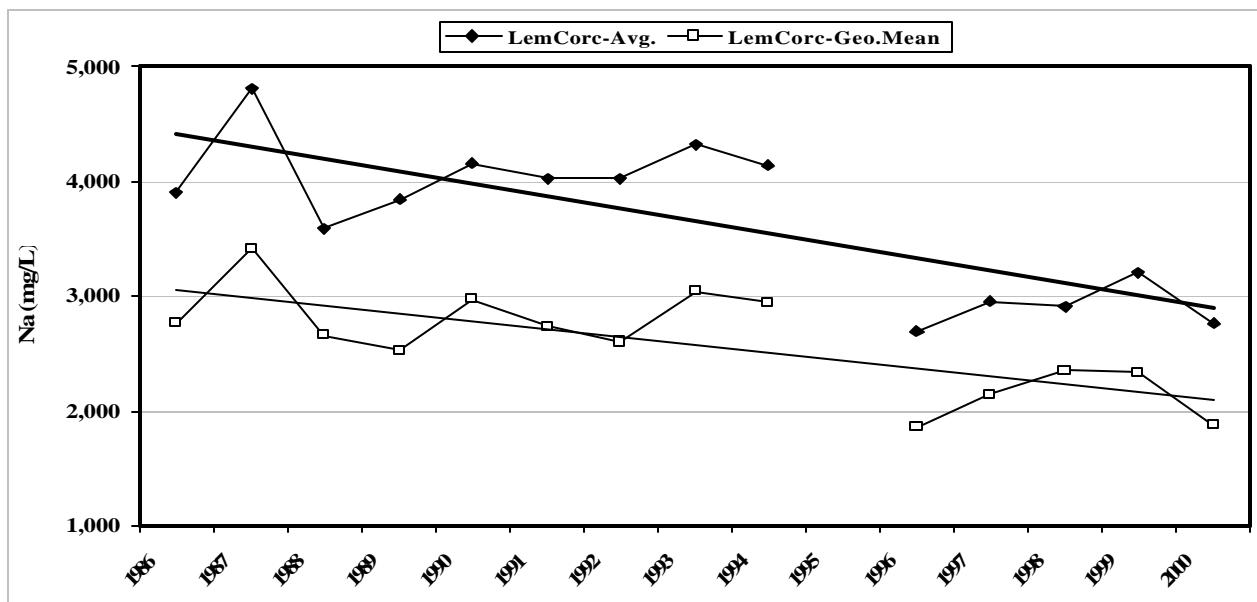


FIGURE 20
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 SODIUM IN LOST HILLS-SEMITROPIC STATIONS
 1986 through 2000

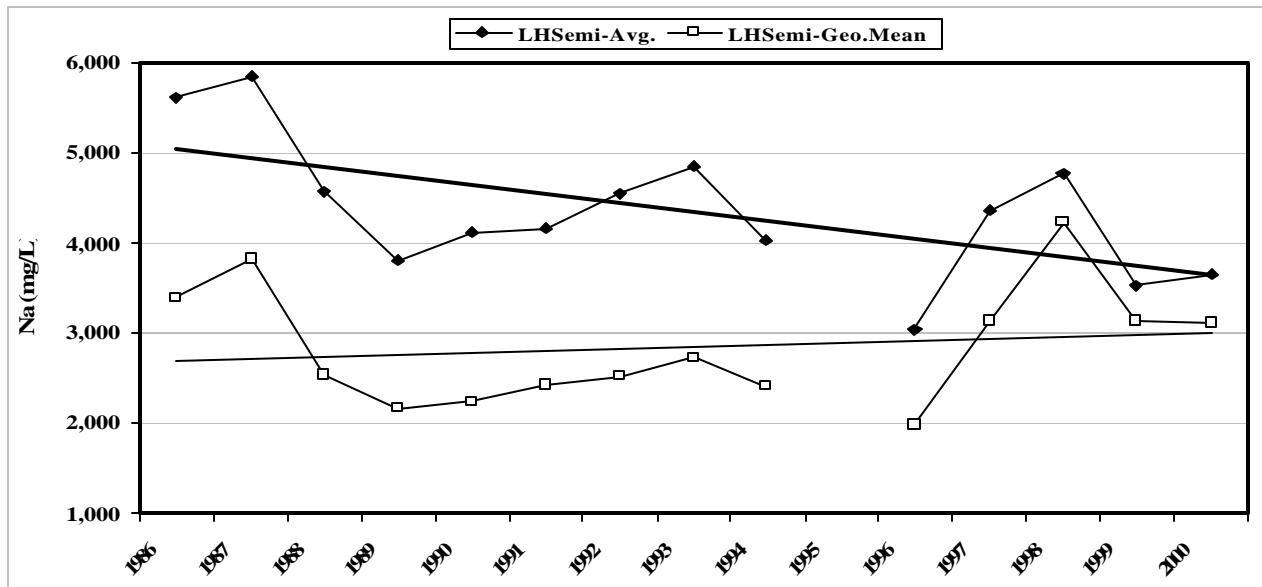
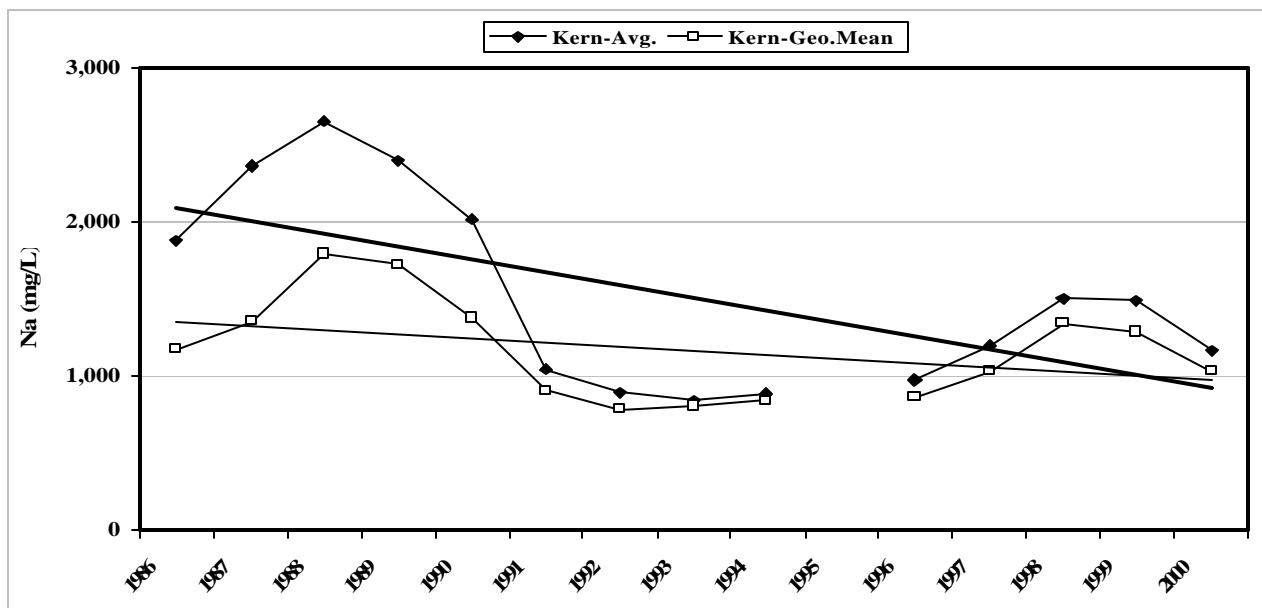


FIGURE 21
 AVERAGE AND GEOMETRIC MEAN TREND LINES FOR
 SODIUM IN KERN LAKEBED STATIONS
 1986 through 2000



Pesticides

Extensive sampling and analyses by federal and State agencies prior to 1986 have shown that pesticides are not often detected in valley subsurface water. As a result, the drainage-monitoring program did not include testing for pesticides in 2000.

Nutrients

The drainage-monitoring program has not sampled subsurface drains for nutrients since 1987, when total ammonia and organic nitrogen, dissolved nitrate and nitrite, dissolved ammonia, dissolved orthophosphate, and total phosphorous were last analyzed. Originally, nutrient data were to be analyzed for correlation of nutrient values versus the time of year when sampled. This relationship was difficult to evaluate due to:

1. Over-irrigation, which leads to increased leaching of salts from soils.
2. Variable commercial fertilizer application rates.
3. Yearly sample value fluctuations.
4. Variable soil types.

Thus, nutrient trends are not examined in the report.

Trace Elements

Trace elements occur naturally in rock and soil. Included are aluminum, barium, cadmium, cobalt, copper, iron, lead, mercury, silver, and zinc, which historically have been very low or undetectable in drainage sump water; consequently, they have not been sampled since 1987. Selenium is the only trace element sampled for in 2000.

Selenium

Selenium is a naturally occurring, nonmetallic chemical element that accumulates in drainage water when selenium-enriched salts are leached from the soil into the shallow groundwater. Water-quality problems associated with selenium are most likely in areas of the San Joaquin Valley where soils are formed of sediments from marine sedimentary rocks of the Coast Range. The occurrence of Coast Range sediments and the highest selenium concentrations are clearly linked throughout the valley. Three areas of the western valley – (1) the alluvial fans near Panoche and Cantua Creeks in the central western valley, (2) an area west of the town of Lost Hills, and (3) the Buena Vista Lake Bed area – have the highest soil selenium concentrations. High concentrations of selenium occur in subsurface drain water from some agricultural lands near, but not necessarily within, all three areas.

Selenium for the central subsurface drains ranged from 0.006 to 0.356 mg/L. All southern stations recorded measurable levels of selenium, varying from 0.001 to 1.03 mg/L. The Kern Lakebed station COC 5329 recorded the uppermost levels ranging from 0.485 mg/L to 1.03 mg/L. Selenium levels from 1986 through 2000 are listed in Table 9.

TABLE 9
SELENIUM IN SUBSURFACE DRAINS
1986 through 2000
 (milligrams per Liter)

Arithmetic Average Geometric Mean															2000	
1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Min	Max
Central Area																
0.099	0.110	0.095	0.090	0.085	0.091	0.066	0.071	0.077	0.077	0.089	0.080	0.086	0.114	0.006	0.356	
0.061	0.053	0.057	0.053	0.053	0.050	0.042	0.054	0.050	0.049	0.061	0.059	0.057	0.080			
Southern Area																
<i>Lemoore-Corcoran</i>																
0.004	0.004	0.007	0.009	0.009	0.007	0.006	0.010	0.005	0.007	0.004	0.005	0.009	0.015	0.001	0.032	
0.003	0.003	0.004	0.005	0.005	0.005	0.004	0.006	0.004	0.005	0.003	0.004	0.007	0.012			
<i>Lost Hills-Semtropic</i>																
0.155	0.191	0.129	0.117	0.095	0.132	0.154	0.124	0.144	0.152	0.147	0.191	0.134	0.153	0.008	0.488	
0.034	0.059	0.022	0.020	0.017	0.032	0.033	0.029	0.035	0.049	0.067	0.079	0.045	0.086			
<i>Kern Lakebed</i>																
0.115	0.124	0.157	0.177	0.094	0.049	0.101	0.094	0.152	0.099	0.085	0.118	0.141	0.293	0.024	1.030	
0.041	0.043	0.078	0.073	0.044	0.027	0.025	0.026	0.032	0.040	0.045	0.063	0.052	0.098			

No data collected in 1995.

Trends

Water quality trends are examined (in milliequivalents per liter) for the cations sodium, calcium, and magnesium. The trend line of each constituent is recognized with a beginning and ending period of analyses. Through linear regression the data are interpreted to form a line that charts a change of each constituent over time. The percentage increase or decrease of a trend line is evaluated by the numerical difference between the point of beginning and ending of the linear regression. Included are the first year of analyses and total sampled years the data represent. Tables 9 through 12 show the trend data for the central and southern area drains. In addition, a graphed figure representing each central and southern station are given in Appendixes C and D, respectively.

All eleven central subsurface drains show a decline in sodium. Station FBH 8061 showed the greatest decline of 82% that spanned over a 41-year period. Calcium levels rose in six stations with station DPS 1367 showing the greatest increase at 67%. Magnesium declined in seven stations with the greatest decrease of 32% for stations DPS 2535 and HMH 7516.

The two surface drains in the Central Area contrast one another. Over a 24-year period, station CTL 4504's sodium, calcium, and magnesium levels declined 63%, 65%, and 69%, respectively. In contrast, station DPS 3235 increased 121%, 218%, and 113 % in sodium, calcium, and magnesium, respectively, over a 34-year trend of analyses.

Sodium declined at seven of the nine Lemoore-Corcoran stations with station ERR 7525 showing the greatest decrease of 67% over a 33-year period. The greatest calcium increase of 25% is recorded for station ERR 8429. The greatest drop in calcium of 50% is noted for station ERR 7525. Magnesium declined in eight stations with station ERR 7525 showing the greatest decrease of 67%.

Five of the six Lost Hills-Semitropic stations declined in sodium, calcium, and magnesium. Over a span of 15 years, station HCH 7439's sodium, calcium, and magnesium concentrations declined more than any of the other sub-area stations at 100%, 50%, and 100%, respectively. Station LNW 5467 showed an increase in sodium and magnesium at 29% and 60%, respectively, while calcium remained unchanged.

The trends for the three stations in the Kern Lakebed sub-area varied. Station CNR 0801's sodium and magnesium concentrations declined 42% and 24%, while the calcium rose 7%. Sodium and calcium concentrations rose 4% each and magnesium declined 8% for station COC 4126. Lastly, station COC 5329's sodium, calcium, and magnesium concentrations all rose 22%, 36%, and 41 %, respectively.

TABLE 10
CATION TREND LINE DATA
CENTRAL DRAINS

Station	Constituent	Trend Line**		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
BVS 6016	Sodium	40	36	4	-10	1971	29
	Calcium	21	19	2	-7	1971	29
	Magnesium	15	11	3	-22	1971	29
BVS 8003	Sodium	95	70	25	-26	1966	34
	Calcium	17	19	2	9	1966	34
	Magnesium	21	19	2	-10	1966	34
CTL 4504*	Sodium	27	10	17	-63	1976	24
	Calcium	15	5	10	-65	1976	24
	Magnesium	8	3	6	-69	1976	24
DPS 1367	Sodium	27	22	5	-17	1967	33
	Calcium	18	30	12	67	1967	33
	Magnesium	8	11	3	31	1967	33
DPS 2535	Sodium	97	65	32	-33	1971	29
	Calcium	31	20	11	-35	1971	29
	Magnesium	24	16	8	-33	1971	29
DPS 3235*	Sodium	14	31	17	121	1966	34
	Calcium	6	18	12	218	1966	34
	Magnesium	4	9	4.5	113	1966	34
DPS 3465	Sodium	54	47	8	-14	1974	26
	Calcium	25	25	0	0	1974	26
	Magnesium	16	15	1	-6	1974	26
DPS 4616	Sodium	96	62	34	-35	1961	39
	Calcium	17	22	5	29	1961	39
	Magnesium	20	29	8.5	43	1961	39
FBH 2016	Sodium	87	50	37	-43	1960	40
	Calcium	19	20	1	5	1961	39
	Magnesium	25	19	6	-22	1961	39
FBH 8061	Sodium	68	12	56	-82	1959	41
	Calcium	16	17	1	3	1961	39
	Magnesium	11	10	1	-9	1961	39
HMH 7516	Sodium	23	18	5	-22	1967	33
	Calcium	18	13	5	-28	1967	33
	Magnesium	6	4	2	-33	1967	33

*Surface Drains

**Data in meq/L

TABLE 11
CATION TREND LINE DATA
LEMOORE-CORCORAN STATIONS

Station	Constituent	Trend Line**		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
CCN 3550	Sodium	28	33	5	16	1966	34
	Calcium	11	12	1	11	1966	34
	Magnesium	9	9	1	6	1966	34
ERR 7525	Sodium	107	35	72	-67	1967	33
	Calcium	14	7	7	-50	1967	33
	Magnesium	18	6	12	-67	1967	33
ERR 8429	Sodium	48	54	7	14	1985	15
	Calcium	3	4	1	25	1985	15
	Magnesium	5	5	0	-2	1985	15
ERR 8641	Sodium	270	120	150	-56	1985	15
	Calcium	16	15	1	-6	1985	15
	Magnesium	60	22	38	-63	1985	15
GSY 0855	Sodium	175	100	75	-43	1967	33
	Calcium	15	17	2	13	1967	33
	Magnesium	35	25	10	-29	1967	33
SFD 2727	Sodium	72	40	32	-44	1982	18
	Calcium	13	13	0	0	1982	18
	Magnesium	53	25	28	-52	1982	18
VGD 3906	Sodium	360	260	100	-28	1985	15
	Calcium	18	20	2	11	1985	15
	Magnesium	87	45	42	-48	1985	15
VGD 4406	Sodium	350	310	40	-11	1985	15
	Calcium	20	19	1	-5	1985	15
	Magnesium	81	52	29	-36	1985	15
VGD 5412	Sodium	200	190	10	-5	1985	15
	Calcium	20	17	3	-15	1985	15
	Magnesium	57	33	24	-42	1985	15

**Data in meq/L

TABLE 12
CATION TREND LINE DATA
LOST HILLS-SEMITROPIC STATIONS

Station	Constituent	Trend Line**		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
HCH 7439	Sodium	160	0	160	-100	1985	15
	Calcium	6	3	3	-50	1985	15
	Magnesium	18	0	18	-100	1985	15
LNW 5454	Sodium	340	205	135	-40	1985	15
	Calcium	25	24	1	-4	1985	15
	Magnesium	26	17	9	-35	1985	15
LNW 5467	Sodium	95	123	28	29	1985	15
	Calcium	28	28	0	0	1985	15
	Magnesium	10	16	6	60	1985	15
LNW 6459	Sodium	650	400	250	-38	1985	15
	Calcium	30	27	3	-8	1985	15
	Magnesium	44	23	21	-48	1985	15
LNW 6467	Sodium	330	175	155	-47	1985	15
	Calcium	29	28	1	-3	1985	15
	Magnesium	30	24	6	-20	1985	15
STC 5436	Sodium	287	113	174	-61	1975	25
	Calcium	8	5	3	-40	1975	25
	Magnesium	7	3	4	-57	1975	25

**Data in meq/L

TABLE 13
CATION TREND LINE DATA
KERN LAKEBED STATIONS

Station	Constituent	Trend Line**		Difference		Years	
		Begin	End	Numerical	%	Begin	Total
CNR 0801	Sodium	112	65	47	-42	1985	15
	Calcium	15	16	1	7	1985	15
	Magnesium	25	19	6	-24	1985	15
CO 4126	Sodium	26	27	1	4	1985	15
	Calcium	28	29	1	4	1985	15
	Magnesium	13	12	1	-8	1985	15
CO 5329	Sodium	45	55	10	22	1985	15
	Calcium	22	30	8	36	1985	15
	Magnesium	11	16	5	41	1985	15

**Data in meq/L

DWR'S FUTURE MONITORING PROGRAM

Plans are being formulated to modify and redirect activities of DWR'S ongoing monitoring program. Currently, a plan is being developed to replace non-functioning flow accumulator meters on existing sumps and to install flow accumulators on new sumps. This work involves cooperation and participation from water and drainage districts and from willing growers. Protocols to collect data from the various districts are being refined so that data can be obtained and evaluated in a timely manner.

The two databases that store groundwater and sump data are being refined. Also, the 2001 report will involve evaluation of anion trends, as well as a 2001 Electrical Conductivity map. In addition, plans are being made to solicit regulatory agencies for appropriate drainage data that can be included in the annual report. Lastly, water quality sampling will be modified yearly to address specific constituent issues.

APPENDIX A
MINERAL ANALYSES IN DRAINAGE SUMPS
CENTRAL AREA

APPENDIX A
MINERAL ANALYSES OF CENTRAL AREA DRAINS
2000

Station	Date Time	Temp. °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC (µS/cm)	Ca	Mg	Na	NO ₃	B	TDS Sum	TH	

BVS 6016

03/09/2000 1315	15 59	7.4 8.0	4,900 4,950	342 17.07	131 10.77	626 27.22	35.2 0.57	4.7 -	3,888 -	1,394 -	7.3 -
05/09/2000 1045	18 64	7.3 7.8	6,198 6,190	423 21.11	164 13.49	873 37.96	214.0 3.45	6.2 -	5,040 -	1,732 -	9.1 -
07/11/2000 945	21 70	7.2 7.9	5,990 5,920	418 20.86	148 12.17	835 36.30	228.0 3.68	5.5 -	4,830 -	1,654 -	8.9 -
09/12/2000 1330			7,510 7,460	378 18.86	148 12.17	1420 61.74	184.0 2.97	10.9 -	6,200 -	1,554 -	15.7 -
11/06/2000 1415	20 68	7.3 7.8	7,190 7,070	381 19.01	138 11.35	1340 58.26	160.0 2.58	9.8 -	5,860 -	1,520 -	15.0 -

BVS 8003

01/11/2000 1300	16 61	7.3 8,710	8,736 17.07	342 17.52	213 70.00	1610 0.81	50.4 -	18.0 -	7,652 -	1,731 -	16.8 -
05/09/2000 1045	18 64	7.5 7.8	9,315 9,300	370 18.46	213 17.52	1690 73.48	83.3 1.34	19.3 -	8,120 -	1,801 -	17.3 -
07/11/2000 1000	21 70	7.4 7.9	8,150 8,070	343 17.12	202 16.61	1480 64.35	74.0 1.19	16.5 -	6,980 -	1,689 -	15.7 -
09/12/2000 1345			5,660 5,620	277 13.82	152 12.50	988 42.96	53.0 0.85	10.9 -	4,630 -	1,318 -	11.8 -
11/06/2000 1415	19 66	7.3 7.9	5,660 5,510	291 14.52	145 11.92	979 42.57	34.0 0.55	11.0 -	4,466 -	1,324 -	11.7 -

APPENDIX A
MINERAL ANALYSES OF CENTRAL AREA DRAINS
2000 (continued)

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (µS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	
CTL 4504												
	01/11/2000 930	8 46	7.9	1,042 711	33 1.62	18 1.46	77.96 3.39	5.9 0.10	0.4	422	154	2.7
	03/09/2000 1030	12 54	8.0 7.7	855 926	53 2.64	20 1.64	84 3.65	1.2 0.02	1.1	550	215	2.5
	05/09/2000 1045	18 64	8.0 7.3	627 540	27 1.34	14 1.14	58.53 2.54	3.6 0.06	0.3	334	124	2.3
	07/11/2000 750	18 64	8.2 8.0	647 632	33 1.62	15 1.21	66.73 2.90	3.9 0.06	0.6	374	142	2.4
	09/12/2000 945			406 406	21 1.02	11 0.94	44.1 1.92	2.9 0.05	0.2	231	98	1.9
	11/06/2000 1415	16 61	8.2 7.9	506 501	20 1.01	12 1.01	61.56 2.68	3.3 0.05	0.2	279	101	2.7
DPS 1367												
	01/11/2000 1200	17 63	7.3	5,239 5,210	530 26.45	120 9.87	528 22.96	210.0 3.39	5.2	4,062	1,818	5.4
	03/09/2000 1230	17 63	7.4 7.6	5,428 5,600	590 29.44	130 10.69	510 22.17	219.0 3.53	5.0	4,170	2,009	5.0
	05/09/2000 1045	18 64	7.3 7.9	5,532 5,470	591 29.49	127 10.44	550 23.91	224.0 3.61	5.4	4,260	1,999	5.4
	07/11/2000 815	20 68	7.4 7.9	5,590 5,400	581 28.99	127 10.44	508 22.09	217.0 3.50	4.7	4,260	1,974	5.0
	09/12/2000 1230			5,520 5,490	597 29.79	133 10.94	571 24.83	221.0 3.56	5.3	4,250	2,039	5.5
	11/06/2000 1415	20 68	7.4 7.8	5,670 5,520	634 31.64	140 11.51	577 25.09	207.0 3.34	5.1	4,224	2,160	5.4

APPENDIX A

**MINERAL ANALYSES OF CENTRAL AREA DRAINS
2000 (continued)**

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (μS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	

DPS 2535

01/11/2000	18	7.3	9,660	465	212	1710	101.0	21.0	7,692	2,034	16.5
1100	64		9,910	23.20	17.43	74.35	1.63		-		
03/09/2000	18	7.2	8,050	415	171	1400	20.4	1.1	6,820	1,741	14.6
1130	64		8,790	20.71	14.06	60.87	0.33		-		
05/09/2000	18	7.4	8,016	394	156	1260	87.3	17.0	6,240	1,627	13.6
1045	64		8,000	19.66	12.83	54.78	1.41		-		
07/11/2000	20	7.4	8,190	384	161	1360	88.0	17.9	6,400	1,622	14.7
845	68		8,090	19.16	13.24	59.13	1.42		-		

DPS 3235

01/11/2000	8	8.2	4,869	331	95	658	159.0	8.1	3,662	1,218	8.2
1000	46		4,860	16.52	7.81	28.61	2.56		-		
05/09/2000	18	8.4	4,977	349	94	632	130.0	7.8	3,720	1,259	7.8
1045	64		4,910	17.42	7.73	27.48	2.10		-		
07/11/2000	22	8.2	3,956	274	75	558	80.0	7.5	2,990	994	7.7
900	72		4,020	13.67	6.18	24.26	1.29		-		
09/12/2000			4,680	350	98	664	99.0	8.5	3,510	1,278	8.1
1030				17.47	8.06	28.87	1.60		-		
11/06/2000	17	8.3	5,060	370	101	737	146.0	8.6	3,840	1,340	8.8
1415	63		4,970	18.46	8.31	32.04	2.35		-		

DPS 3465

01/11/2000	16	7.2	8,107	536	199	1190	84.2	16.0	6,528	2,158	11.2
1130	61		8,300	26.75	16.37	51.74	1.36		-		
03/09/2000	17	7.2	7,316	542	196	1080	17.7	14.9	6,260	2,161	10.1
1215	63		8,240	27.05	16.12	46.96	0.29		-		
05/09/2000	17	7.3	7,151	452	159	921	64.2	11.7	5,400	1,784	9.5
1045	63		5,400	22.55	13.08	40.04	1.04		-		
07/11/2000	19	7.2	5,710	394	129	756	60.0	9.6	4,250	1,515	8.5
830	66			19.66	10.61	32.87	0.97		-		
09/12/2000			5,430	519	114	680	63.0	8.0	4,280	1,766	7.0
1145				5,380	25.90	9.38	29.57	1.02		-	

APPENDIX A
MINERAL ANALYSES OF CENTRAL AREA DRAINS
2000 (continued)

Station	Date Time	Temp. °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC (µS/cm)	Ca	Mg	Na	NO ₃	B	TDS Sum	TH	
DPS 4616												

09/12/2000		8,050	398	266	1420	34.0	39.0	6,940	2,090	13.5
1115		7.7	8,000	19.86	21.88	61.74	0.55	-		

FBH 2016

01/11/2000	17	7.3	8,850	438	291	1500	83.7	15.0	7,984	2,292	13.6
1425	63		8,890	21.86	23.93	65.22	1.35	-			
05/09/2000	17	7.3	7,694	414	220	1140	62.9	11.8	6,720	1,940	11.3
1045	63	7.9	7,640	20.66	18.09	49.57	1.01	-			
07/11/2000	20	7.3	7,900	439	238	1350	65.0	13.8	6,980	2,077	12.9
1045	68	7.8	7,900	21.91	19.57	58.70	1.05	-			
09/12/2000			8,270	454	258	1460	65.0	15.1	7,300	2,196	13.6
1015		7.7	8,210	22.65	21.22	63.48	1.05	-			

FBH 8061

01/11/2000	15	7.0	7,316	476	189	1200	41.7	16.0	6,600	1,967	11.8
1330	59		7,390	23.75	15.54	52.17	0.67	-			
05/09/2000	17	7.3	4,213	336	124	545	42.0	6.9	3,570	1,350	6.5
1045	63	8.1	5,400	16.77	10.20	23.70	0.68	-			
07/11/2000	20	7.2	4,796	318	130	693	100.0	8.3	3,970	1,330	8.3
1015	68	8.0	4,810	15.87	10.69	30.13	1.61	-			
09/12/2000			3,271	292	94	398	24.0	5.4	2,660	1,116	5.2
1430		7.8	3,170	14.57	7.73	17.30	0.39	-			
11/06/2000	19	7.1	2,030	221	53	193	5.6	2.5	1,606	770	3.0
1415	66	8.0	2,010	11.03	4.36	8.39	0.09	-			

APPENDIX A
MINERAL ANALYSES OF CENTRAL AREA DRAINS
2000 (continued)

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (µS/cm)	Ca	Mg	Na	NO ₃	B	TDS Sum	

HMH 7516

01/11/2000	17	7.2	3,670	294	59	465	163.0	7.0	2,680	977	6.5
1220	63		3,640	14.67	4.85	20.22	2.63		-		
03/09/2000	17	7.3	3,528	301	60	449	160.0	6.9	2,570	999	6.2
1300	63	7.8	3,640	15.02	4.93	19.52	2.58		-		
05/09/2000	18	7.2	4,467	338	73	530	186.0	7.0	3,380	1,145	6.8
1045	64	7.9	4,440	16.87	6.00	23.04	3.00		-		
09/12/2000			3,564	277	57	471	160.0	7.7	2,520	927	6.7
1245		7.8	3,540	13.82	4.69	20.48	2.58		-		
11/06/2000	20	7.4	3,818	315	62	504	160.0	7.6	2,718	1,042	6.8
1245	68	7.9	3,810	15.72	5.10	21.91	2.58		-		

APPENDIX B
MINERAL ANALYSES IN DRAINAGE SUMPS
SOUTHERN AREA

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS

2000

Station	Date Time	Temp. °C °F	Field		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			Laboratory		Ca	Mg	Na	NO3	B	TDS Sum	TH	
CCN 3550												

09/11/2000	3,224	181	74	595	59.0	1.5	2,560	757	9.4
1015	8.0	3,560	9.03	6.09	25.87	0.95	-	-	-

CNR 0801

01/10/2000	18	7.3	11,270	370	307	2130	165.0	25.0	9,472	2,188	19.8
1100	64		10,580	18.46	25.25	92.61	2.66		-	-	-
05/08/2000	22	7.3	9,434	378	279	1640	244.0	19.8	8,560	2,093	15.6
1100	72	7.8	9,440	18.86	22.94	71.30	3.93		-	-	-
07/10/2000	22	7.4	10,388	336	278	2020	184.0	23.3	9,080	1,984	19.7
1130	72	7.8	10,200	16.77	22.86	87.83	2.97		-	-	-
09/11/2000			9,464	339	293	2030	210.0	25.0	8,880	2,053	19.5
1015		7.8	9,950	16.92	24.10	88.26	3.39		-	-	-

COC 4126

01/10/2000	18	7.0	5,750	544	161	668	341.0	2.8	5,036	2,022	6.5
1100	64		5,460	27.15	13.24	29.04	5.50		-	-	-
03/06/2000	17	7.6	5,275	568	156	602	318.0	2.7	4,794	2,061	5.8
1100	63	7.9	5,340	28.34	12.83	26.17	5.13		-	-	-
05/08/2000	20	7.2	5,550	563	153	666	324.0	2.9	4,790	2,036	6.4
1100	68	7.8	5,300	28.09	12.58	28.96	5.22		-	-	-
07/10/2000	25	7.0	3,200	564	146	505	253.0	2.4	4,570	2,010	4.9
1130	77	7.7	4,880	28.14	12.01	21.96	4.08		-	-	-
09/11/2000			4,655	560	131	577	234.0	3.4	4,330	1,938	5.7
1015		7.5	4,830	27.94	10.77	25.09	3.77		-	-	-
11/06/2000	17	7.4	4,866	512	123	559	213.0	2.9	4,254	1,785	5.8
945	63	8.4	4,820	25.55	10.12	24.30	3.43		-	-	-

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS 2000 (continued)

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (μS/cm)	Ca	Mg	Na	NO ₃	B	TDS Sum	

COC 5329

01/10/2000	16	7.2	9,438	580	197	1420	281.0	9.5	7,484	2,260	13.0
1100	61		8,620	28.94	16.20	61.74	4.53		-		
03/06/2000	17	7.0	8,142	589	188	1250	291.0	7.9	7,044	2,245	11.5
1100	63	7.6	8,290	29.39	15.46	54.35	4.69		-		
05/08/2000	21	7.3	8,424	574	189	1310	352.0	8.4	7,160	2,212	12.1
1100	70	7.8	8,260	28.64	15.54	56.96	5.68		-		
07/10/2000	24	7.2	6,936	594	177	977	418.0	6.0	6,180	2,213	9.0
1130	75	7.8	7,060	29.64	14.56	42.48	6.74		-		
09/11/2000			7,038	594	184	1170	319.0	8.7	6,260	2,241	10.8
1015		7.6	7,280	29.64	15.13	50.87	5.14		-		

ERR 7525

01/10/2000	12	7.2	4,322	121	66	768	33.2	1.9	3,088	574	14.0
1100	54		4,150	6.04	5.43	33.39	0.54		-		
03/06/2000	16	7.4	6,292	205	111	1210	86.0	3.0	5,028	969	16.9
1100	61	8.0	6,650	10.23	9.13	52.61	1.39		-		
05/08/2000	22	7.2	7,526	198	107	1220	25.9	2.7	4,990	935	17.4
1100	72	7.9	6,470	9.88	8.80	53.04	0.42		-		
07/10/2000	23	7.3	6,136	173	112	1250	48.0	2.7	4,800	893	18.2
1130	73	8.0	6,330	8.63	9.21	54.35	0.77		-		
09/11/2000			6,448	180	124	1390	23.0	3.3	5,140	960	19.5
1015		7.9	6,730	8.98	10.20	60.43	0.37		-		
11/06/2000	19	7.2	5,580	155	94	1190	16.0	2.8	4,186	774	18.6
945	66	8.7	5,640	7.73	7.73	51.74	0.26		-		

APPENDIX B
MINERAL ANALYSES OF SOUTHERN AREA DRAINS
2000 (continued)

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (µS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	

ERR 8429

01/10/2000	16	7.3	5,082	80	48	948	65.5	2.1	3,280	397	20.7
1100	61		4,550	3.99	3.95	41.22	1.06		-		
03/06/2000	17	7.8	4,838	75	49	952	70.0	2.2	3,472	389	21.0
1100	63	8.0	4,970	3.74	4.03	41.39	1.13		-		
05/08/2000	22	7.5	6,254	98	70	1290	53.8	2.4	4,620	533	24.3
1100	72	8.1	6,310	4.89	5.76	56.09	0.87		-		
07/10/2000	22	7.3	2,332	44	24	510	83.0	1.5	1,690	209	15.4
1130	72	8.2	2,520	2.20	1.97	22.17	1.34		-		
09/11/2000			5,830	97	69	1330	43.0	2.8	4,340	526	25.2
1015			6,030	4.84	5.67	57.83	0.69		-		
11/06/2000	21	7.4	6,980	111	80	1540	10.0	2.8	10,740	607	27.2
945	70	8.6	13,100	5.54	6.58	66.96	0.16		-		

ERR 8641

01/10/2000	16	7.1	16,940	309	366	3510	1.9	4.0	14,410	2,279	32.0
1100	61		16,400	15.42	30.10	152.6	0.03		-		
03/06/2000	17	7.4	15,340	311	379	3530	7.9	3.9	14,460	2,338	31.8
1100	63	7.8	16,300	15.52	31.17	153.4	0.13		-		
05/08/2000	23	7.3	14,456	329	364	3620	12.3	4.2	14,500	2,321	32.7
1100	73	8.0	16,100	16.42	29.93	157.3	0.20		-		
07/10/2000	20	7.2	16,428	313	384	3640	8.6	4.1	14,800	2,363	32.6
1130	68	7.9	16,600	15.62	31.58	158.2	0.14		-		
09/11/2000			16,092	275	372	3760	6.1	4.6	14,500	2,219	34.8
1015			16,500	13.72	30.59	163.4	0.10		-		

GSY 0855

01/10/2000	13	6.9	6,630	281	122	1120	34.7	2.1	5,020	1,204	14.0
1100	55		6,220	14.02	10.03	48.70	0.56		-		
09/11/2000			11,340	313	307	2560	11.0	3.9	10,300	2,046	24.6
1015			11,900	15.62	25.25	111.3	0.18		-		
11/06/2000	19	7.2	8,110	229	193	1750	10.0	2.5	6,188	1,367	20.6
945	66	8.6	8,200	11.43	15.87	76.09	0.16		-		

APPENDIX B
MINERAL ANALYSES OF SOUTHERN AREA DRAINS
2000 (continued)

Station	Date _____ Time	Temp. _____ °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC (µS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	TH	

HCH 7439

01/10/2000	15	7.9	9,424	111	80	1780	1.4	5.4	6,276	607	31.5
1100	59		8,500	5.54	6.58	77.39	0.02		-		
03/06/2000	16	8.4	9,438	113	92	1870	6.3	5.0	6,840	661	31.7
1100	61	8.2	9,470	5.64	7.57	81.30	0.10		-		
05/08/2000	23	7.9	7,280	97	77	1570	3.8	4.4	5,510	559	28.9
1100	73	8.3	7,700	4.84	6.33	68.26	0.06		-		
07/10/2000	20	8.1	6,882	81	66	1530	3.5	4.4	5,090	474	30.6
1130	68	8.3	7,170	4.04	5.43	66.52	0.06		-		
09/11/2000			6,264	69	60	1410	2.5	4.7	4,450	419	30.0
1015			6,330	3.44	4.93	61.30	0.04		-		
11/06/2000	20	8.0	4,282	63	42	909	10.0	3.2	2,900	330	21.8
945	68	8.6	4,290	3.14	3.45	39.52	0.16		-		

LME 7569

03/06/2000	15	7.2	1,860	81	23	332	46.0	0.6	1,304	297	8.4
1100	59	8.2	2,000	4.04	1.89	14.43	0.74		-		

LNW 5454

03/06/2000	16	8.0	24,079	488	231	5450	184.0	50.0	19,640	2,170	50.9
1100	61	7.8	23,800	24.35	19.00	236.9	2.97		-		
05/08/2000	23	7.9	19,968	483	216	5200	156.0	49.0	18,700	2,096	49.4
1100	73	7.9	22,200	24.10	17.76	226.0	2.52		-		
07/10/2000	21	7.4	20,304	481	194	4460	135.0	43.9	17,300	2,000	43.4
1130	70	7.8	20,600	24.00	15.95	193.9	2.18		-		
09/11/2000			22,154	513	242	5620	154.0	49.0	19,300	2,278	51.3
1015			23,300	25.60	19.90	244.3	2.48		-		
11/06/2000	20	7.4	22,350	429	218	5610	125.0	44.0	18,010	1,969	55.0
945	68	8.1	22,000	21.41	17.93	243.9	2.02		-		

APPENDIX B
MINERAL ANALYSES OF SOUTHERN AREA DRAINS
2000 (continued)

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (μS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	

LNW 5467

01/10/2000	17	7.4	11,800	532	144	2100	255.0	15.0	8,980	1,922	20.9
1100	63		11,140	26.55	11.84	91.30	4.11		-		
03/06/2000	17	7.6	10,620	557	131	1980	280.0	14.7	8,600	1,931	19.6
1100	63	7.9	10,780	27.79	10.77	86.09	4.52		-		
05/08/2000	22	7.6	12,720	540	160	2420	277.0	18.1	10,600	2,008	23.5
1100	72	7.8	12,900	26.95	13.16	105.2	4.47		-		
07/10/2000	22	7.2	9,434	508	108	1760	230.0	12.7	7,630	1,714	18.5
1130	72	7.7	9,320	25.35	8.88	76.52	3.71		-		
09/11/2000			10,600	500	149	2250	232.0	16.2	8,920	1,862	22.7
1015		7.7	11,100	24.95	12.25	97.83	3.74		-		

LNW 6459

07/10/2000	23	7.5	25,168	438	184	6070	135.0	41.1	21,700	1,852	61.4
1130	73	7.9	25,800	21.86	15.13	263.9	2.18		-		
11/06/2000	21	7.6	37,000	504	308	9210	127.0	39.0	30,000	2,527	79.8
945	70	8.0	36,500	25.15	25.33	400.4	2.05		-		

LNW 6467

01/10/2000	16	7.3	21,175	613	297	4040	49.9	25.0	15,570	2,754	33.5
1100	61		20,000	30.59	24.42	175.6	0.80		-		
03/06/2000	17	7.6	22,892	614	343	5060	279.0	32.0	18,100	2,946	40.6
1100	63	7.8	22,700	30.64	28.21	220.0	4.50		-		
05/08/2000	22	7.6	23,320	599	337	5450	258.0	41.0	20,600	2,884	44.2
1100	72	7.8	25,100	29.89	27.71	236.9	4.16		-		
07/10/2000	23	7.4	23,504	549	312	5210	271.0	39.3	19,900	2,656	44.0
1130	73	7.8	23,900	27.40	25.66	226.5	4.37		-		
11/06/2000	21	7.2	17,760	466	262	3840	183.0	24.0	13,630	2,243	35.3
945	70	8.0	17,600	23.25	21.55	166.9	2.95		-		

APPENDIX B

MINERAL ANALYSES OF SOUTHERN AREA DRAINS
2000 (continued)

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (μS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	
SFD 2727												
	01/10/2000	16	6.9	8,470	277	404	1140	66.0	2.4	7,012	2,356	10.2
	1100	61		7,700	13.82	33.22	49.57	1.06		-		
	03/06/2000	16	7.2	10,164	321	612	1690	77.0	3.1	8,436	3,322	12.8
	1100	61	7.9	10,150	16.02	50.33	73.48	1.24		-		
	05/08/2000	20	6.8	1,099	56	30	122	7.5	0.5	739	263	3.3
	1100	68	6.6	1,030	2.79	2.47	5.30	0.12		-		
	07/10/2000	21	7.0	7,128	254	381	1130	65.0	2.4	6,790	2,204	10.5
	1130	70	7.7	7,210	12.67	31.33	49.13	1.05		-		
	11/06/2000	20	6.8	1,456	63	50	208	10.0	0.1	1,093	363	4.8
	945	68	8.3	1,530	3.14	4.11	9.04	0.16		-		
STC 5436												
	01/10/2000	15	7.6	19,840	103	42	4620	55.8	17.0	15,180	430	97.0
	1100	59		19,600	5.14	3.45	200.8	0.90		-		
	05/08/2000	24	7.6	17,442	156	55	4730	24.3	16.5	15,400	616	83.0
	1100	75	8.1	19,800	7.78	4.52	205.6	0.39		-		
	07/10/2000	21	7.8	13,068	93	52	3160	71.0	10.8	9,910	446	65.1
	1130	70	8.1	13,700	4.64	4.28	137.3	1.14		-		
	09/11/2000			6,480	142	57	1550	69.0	4.7	4,800	589	27.8
	1015		7.9	6,940	7.09	4.69	67.39	1.11		-		
VGD 3906												
	01/10/2000	21	7.0	21,060	396	515	5490	37.5	34.0	21,790	3,110	42.9
	1100	70		22,300	19.76	42.35	238.7	0.60		-		
	05/08/2000	17	7.5	20,768	410	461	5300	33.6	34.9	21,700	2,923	42.7
	1100	63	7.9	21,500	20.46	37.91	230.4	0.54		-		
	07/10/2000	20	7.4	20,646	397	455	5050	40.0	32.6	20,600	2,865	41.1
	1130	68	7.9	20,700	19.81	37.42	219.5	0.65		-		
	09/11/2000			20,979	382	511	6020	35.0	35.0	22,900	3,059	47.4
	1015		7.8	22,700	19.06	42.02	261.7	0.56		-		

APPENDIX B
MINERAL ANALYSES OF SOUTHERN AREA DRAINS
2000 (continued)

Station	Date Time	Temp.	Field		Mineral Constituents				Mineral Constituents			SAR
			Laboratory		mg/L	meq/L		(mg/L)	B	TDS Sum	TH	
		°C °F	pH	EC (μS/cm)	Ca	Mg	Na	NO ₃				

VGD 4406

01/10/2000	21	7.1	25,920	378	710	6970	60.2	34.0	27,660	3,868	48.8
1100	70		27,800	18.86	58.39	303.0	0.97		-		
07/10/2000	20	7.4	19,203	406	415	4740	60.0	32.4	19,700	2,723	39.5
1130	68	7.9	19,900	20.26	34.13	206.0	0.97		-		
09/11/2000			22,200	383	578	6600	53.0	36.0	24,900	3,337	49.7
1015		7.8	24,600	19.11	47.53	286.9	0.85		-		
11/06/2000	19	7.6	29,920	298	816	8420	50.0	38.0	30,860	4,105	57.2
945	66	8.2	29,900	14.87	67.11	366.0	0.81		-		

VGD 5412

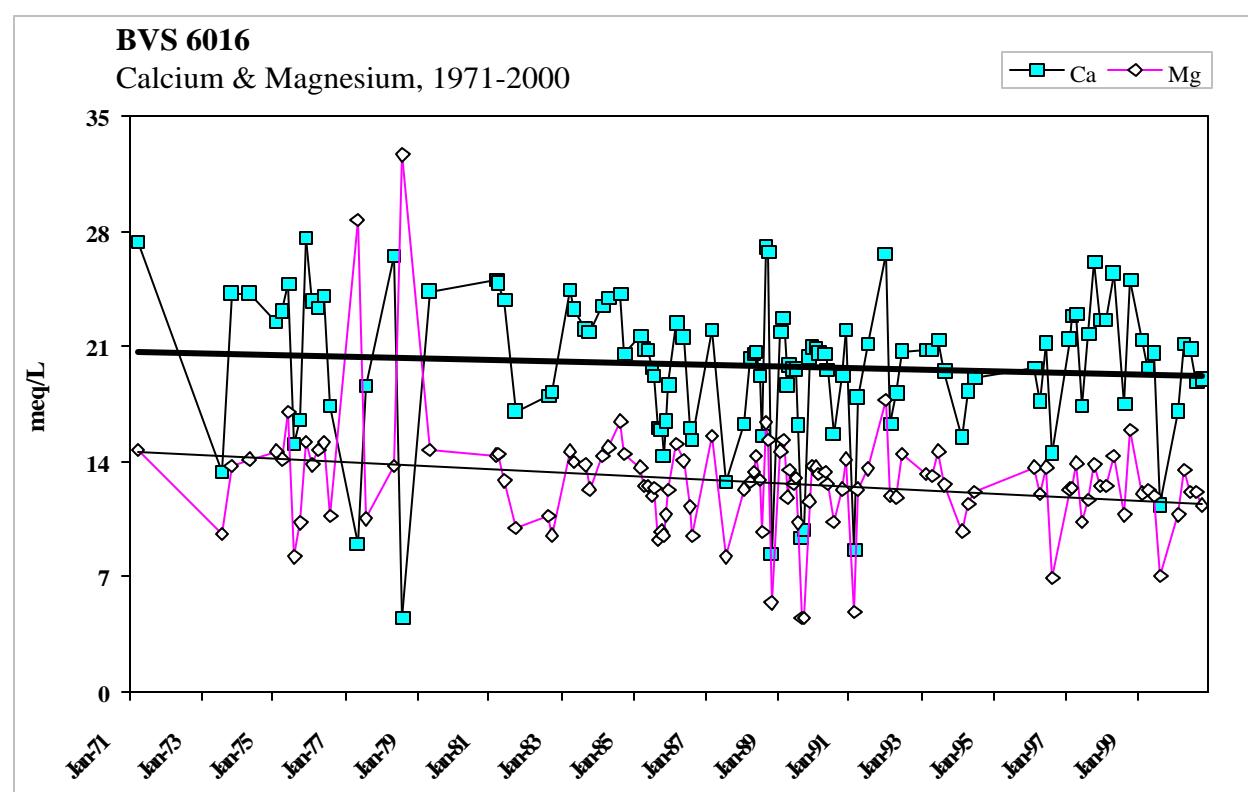
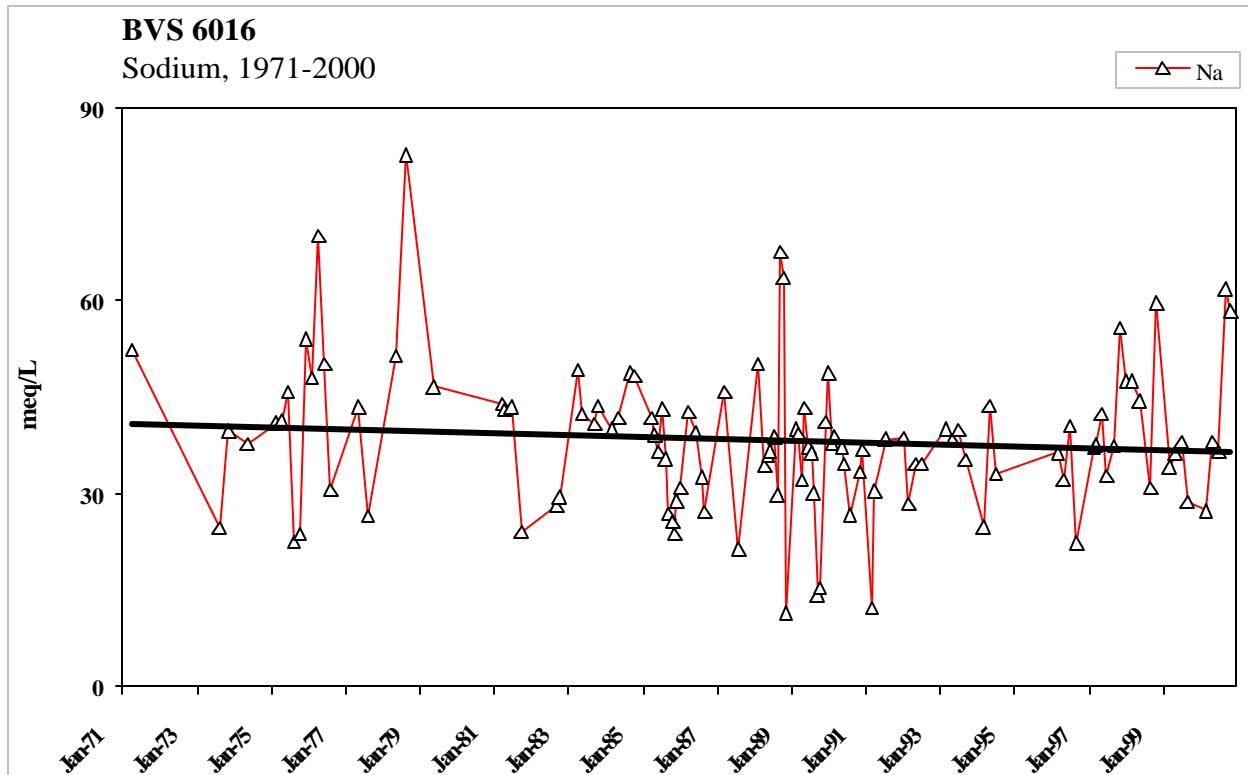
01/10/2000	21	7.0	19,440	360	534	4670	50.4	22.0	19,960	3,098	36.5
1100	70		20,600	17.96	43.91	203.0	0.81		-		
07/10/2000	21	7.3	14,580	369	320	3460	54.0	23.6	13,900	2,240	31.8
1130	70	7.9	14,800	18.41	26.32	150.4	0.87		-		
09/11/2000			14,319	342	347	3970	52.0	26.0	15,300	2,283	36.2
1015		7.9	16,300	17.07	28.54	172.6	0.84		-		
11/06/2000	18	7.6	19,000	266	480	4690	52.0	25.0	17,960	2,641	39.7
945	64	8.1	18,800	13.27	39.47	203.9	0.84		-		

APPENDIX C

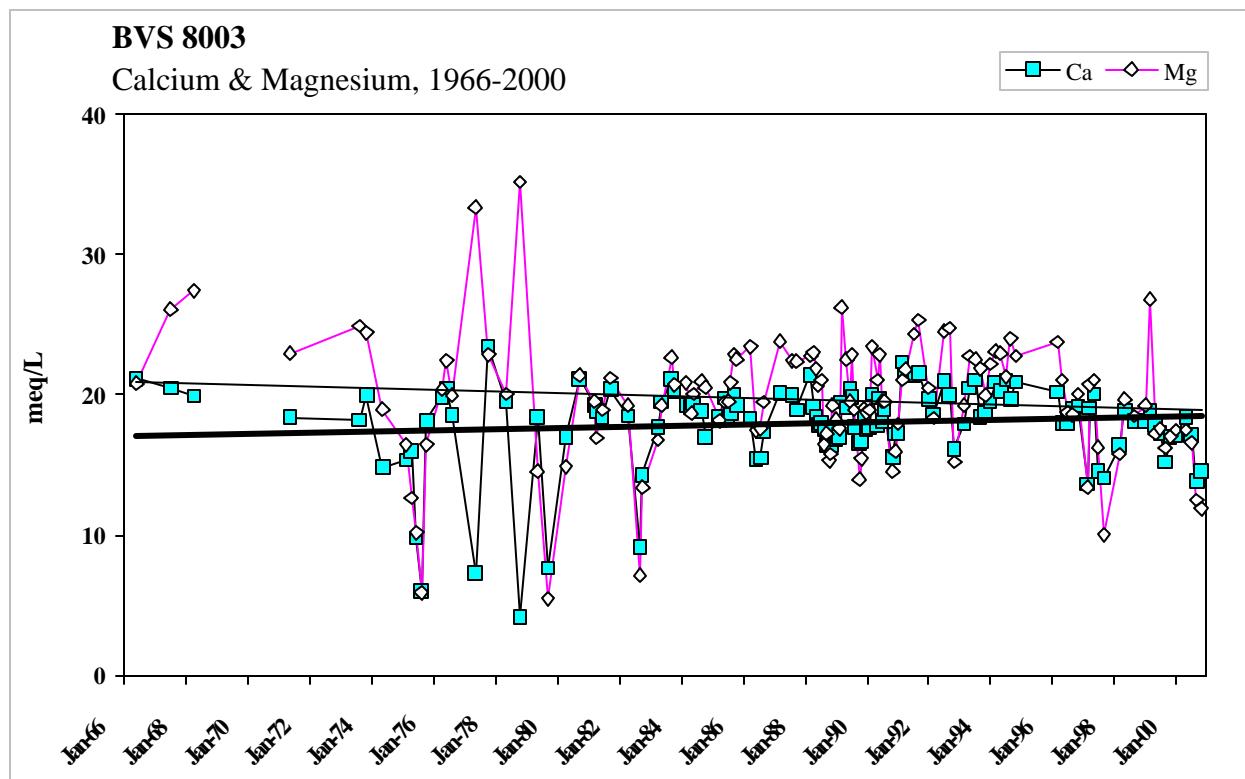
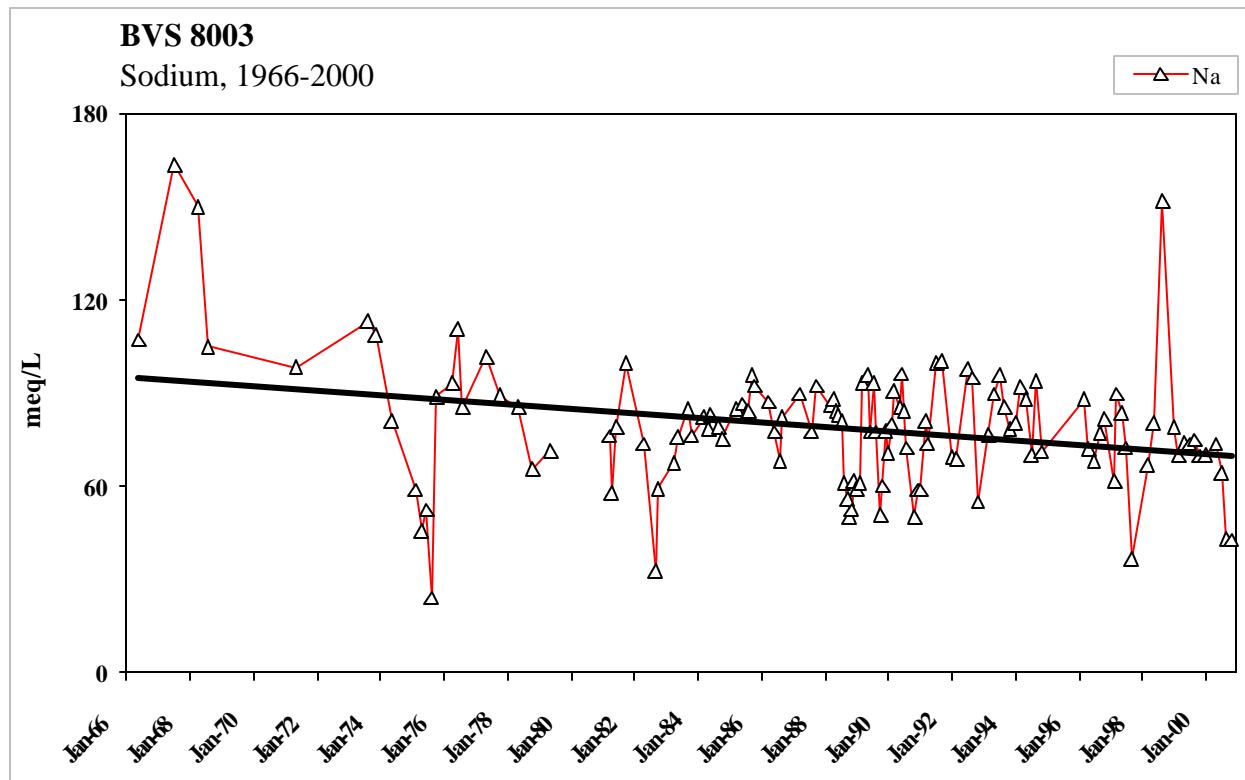
GRAPHS OF WATER QUALITY CATION TRENDS IN DRAINAGE SUMPS

CENTRAL AREA

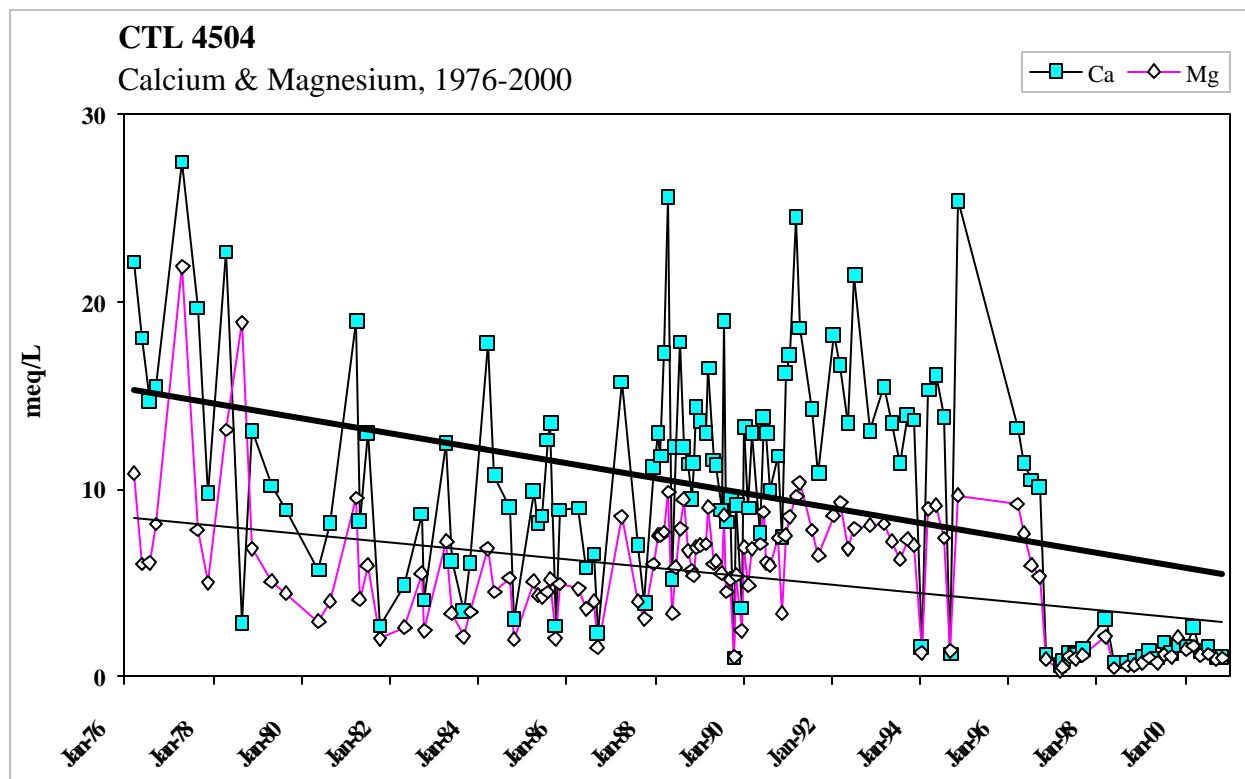
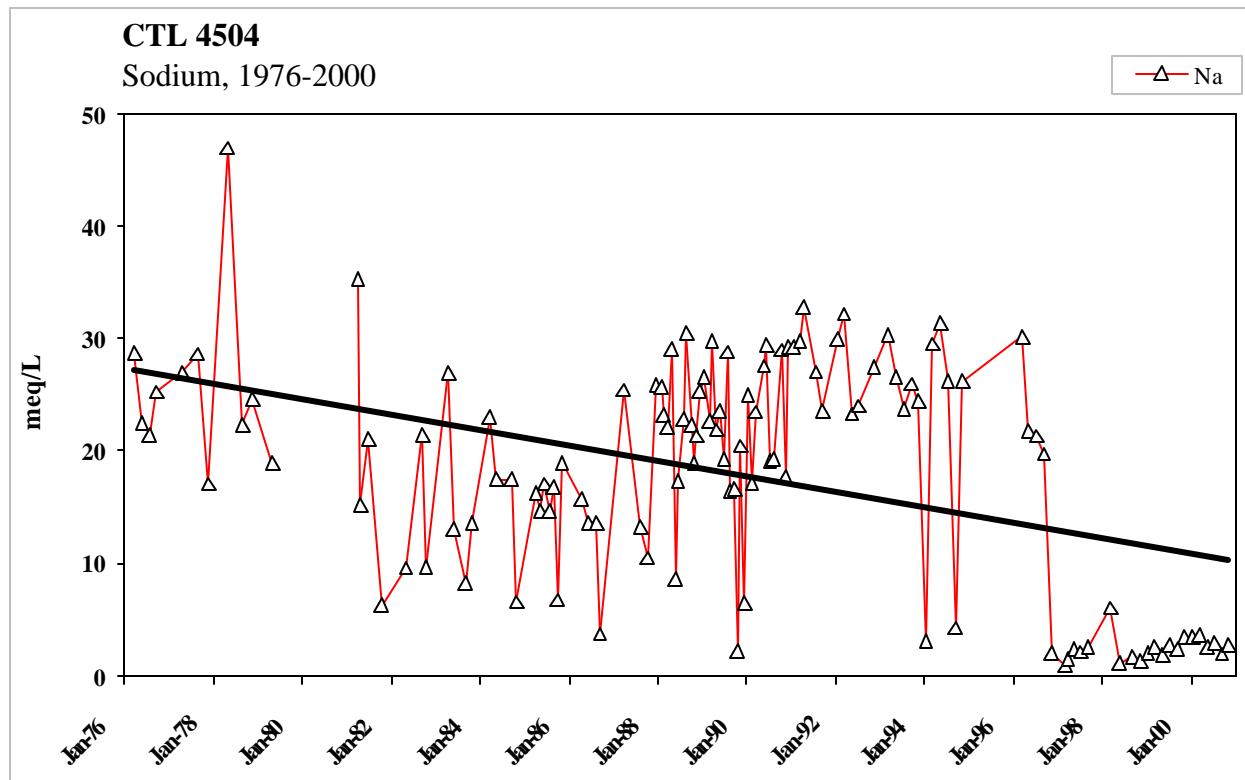
APPENDIX C



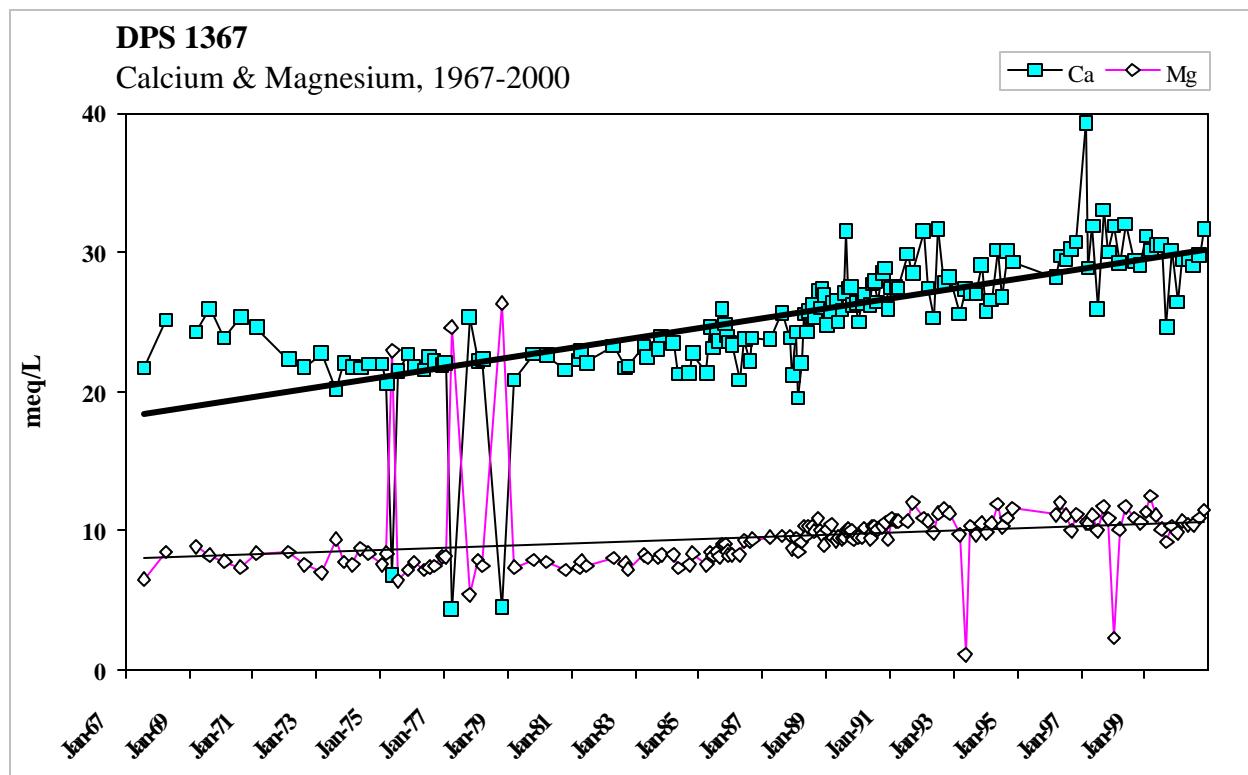
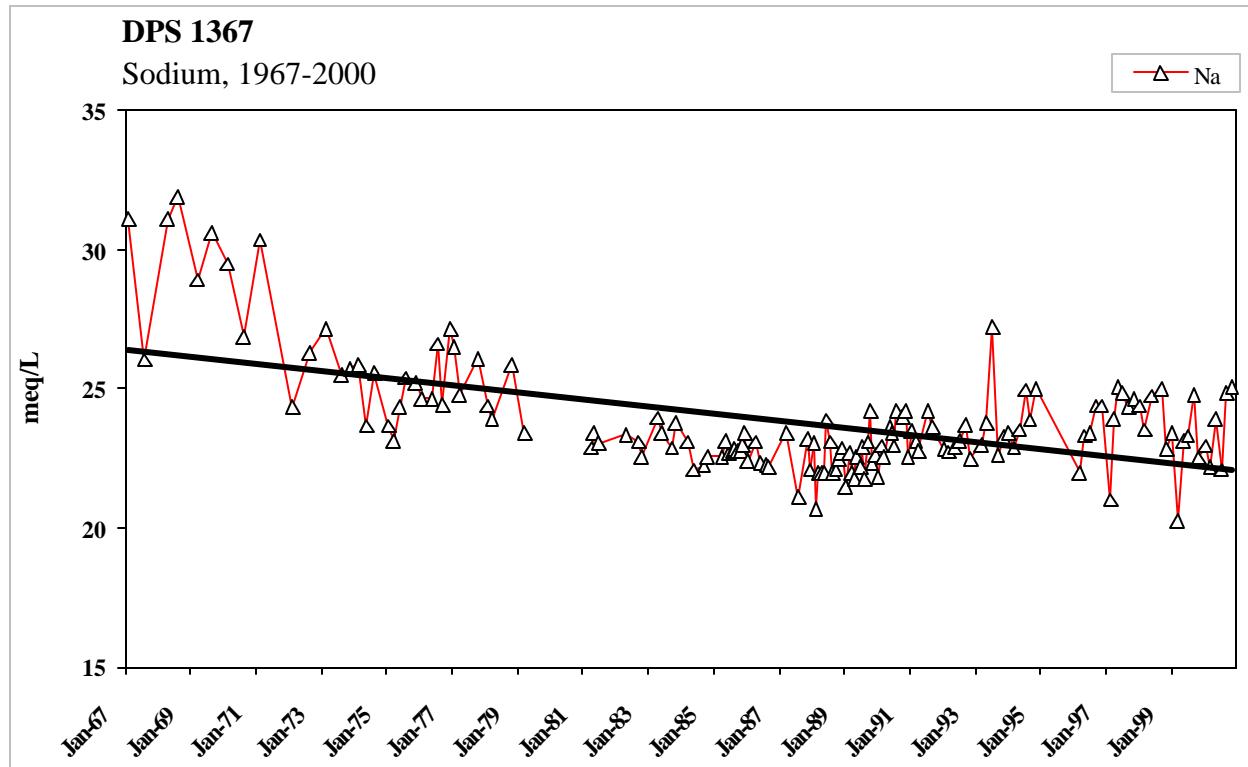
APPENDIX C



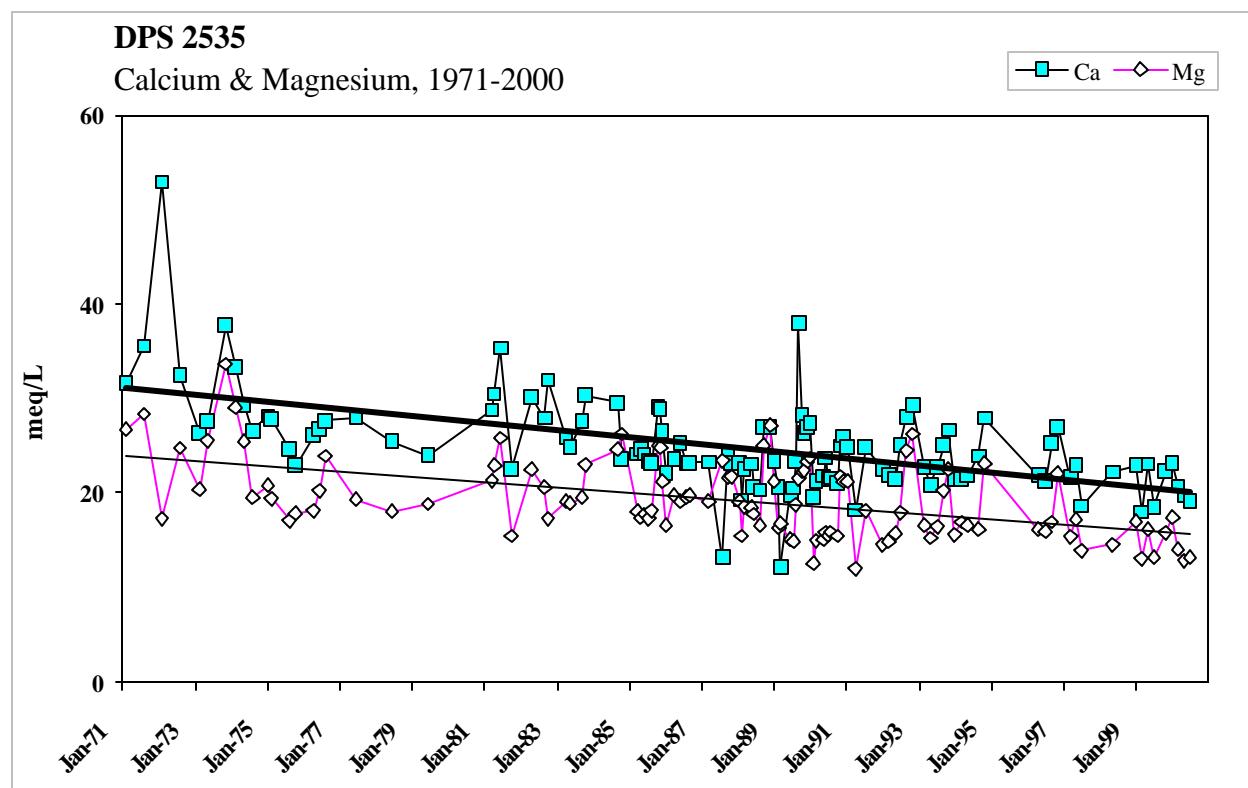
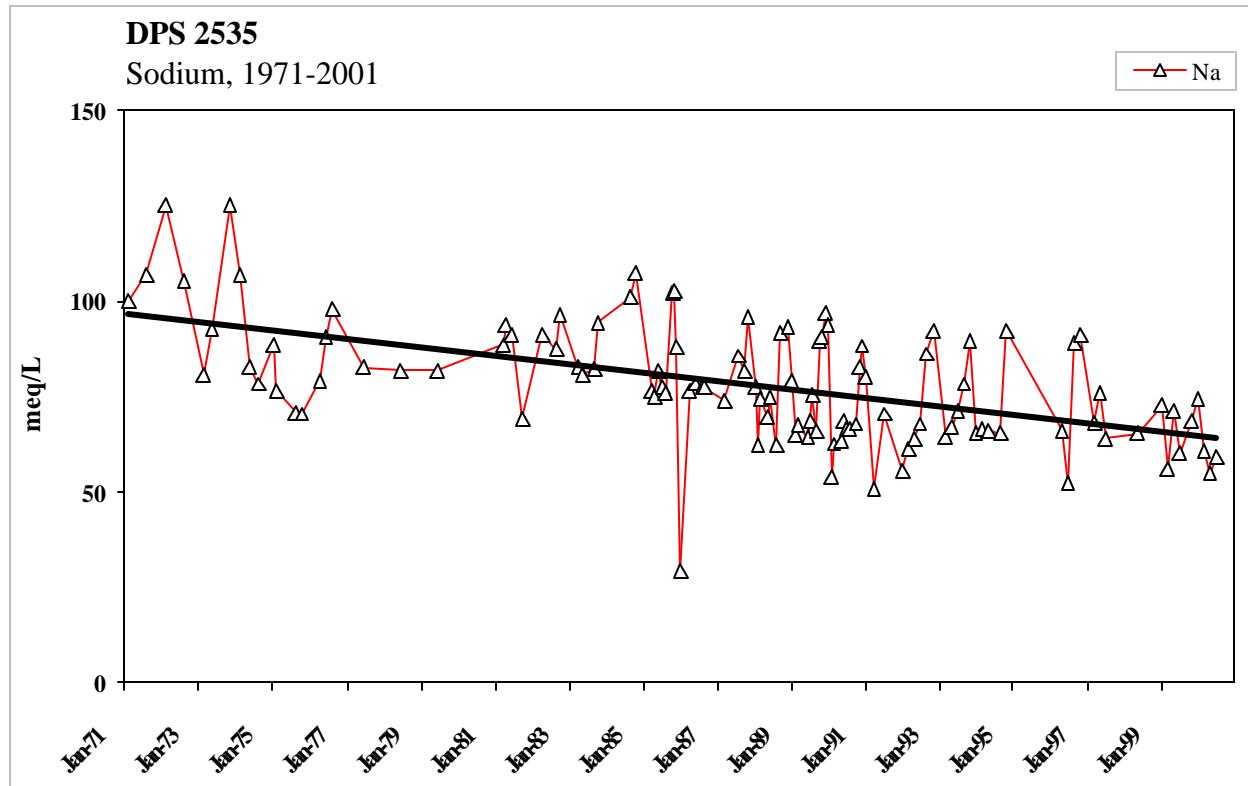
APPENDIX C



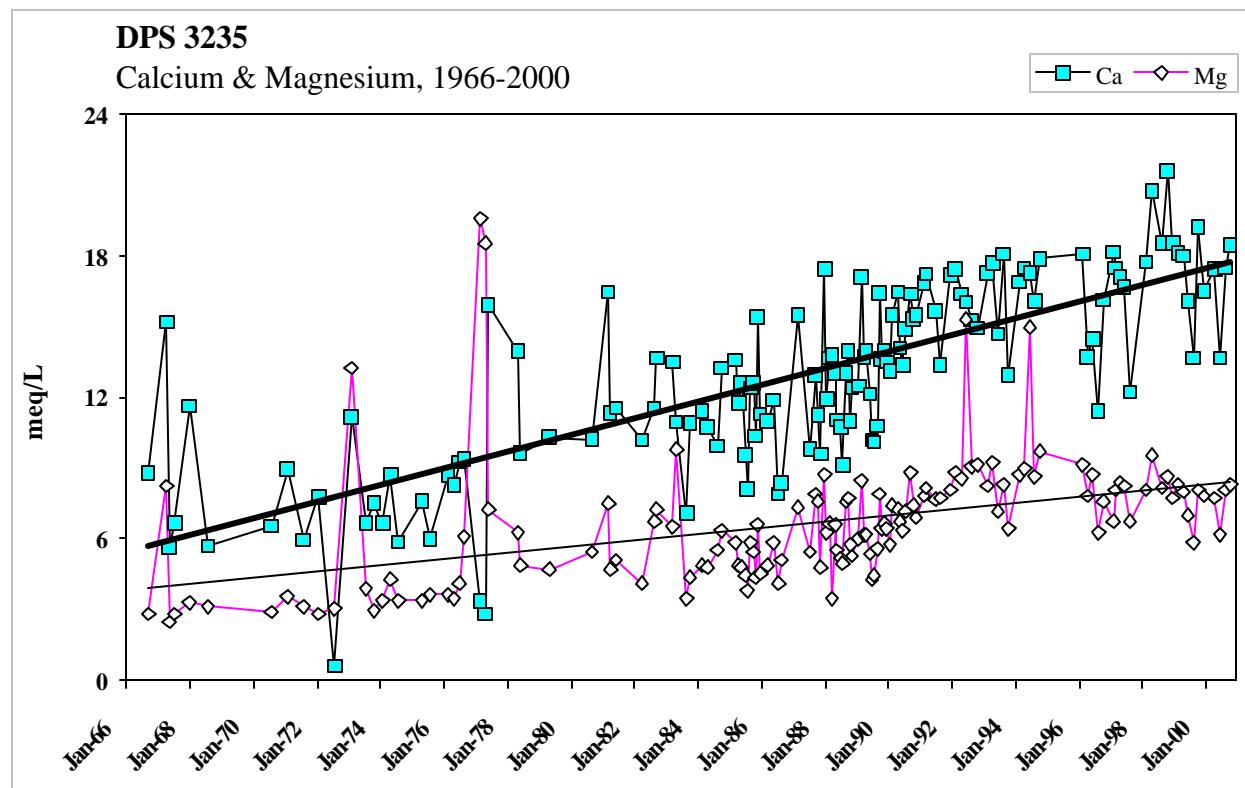
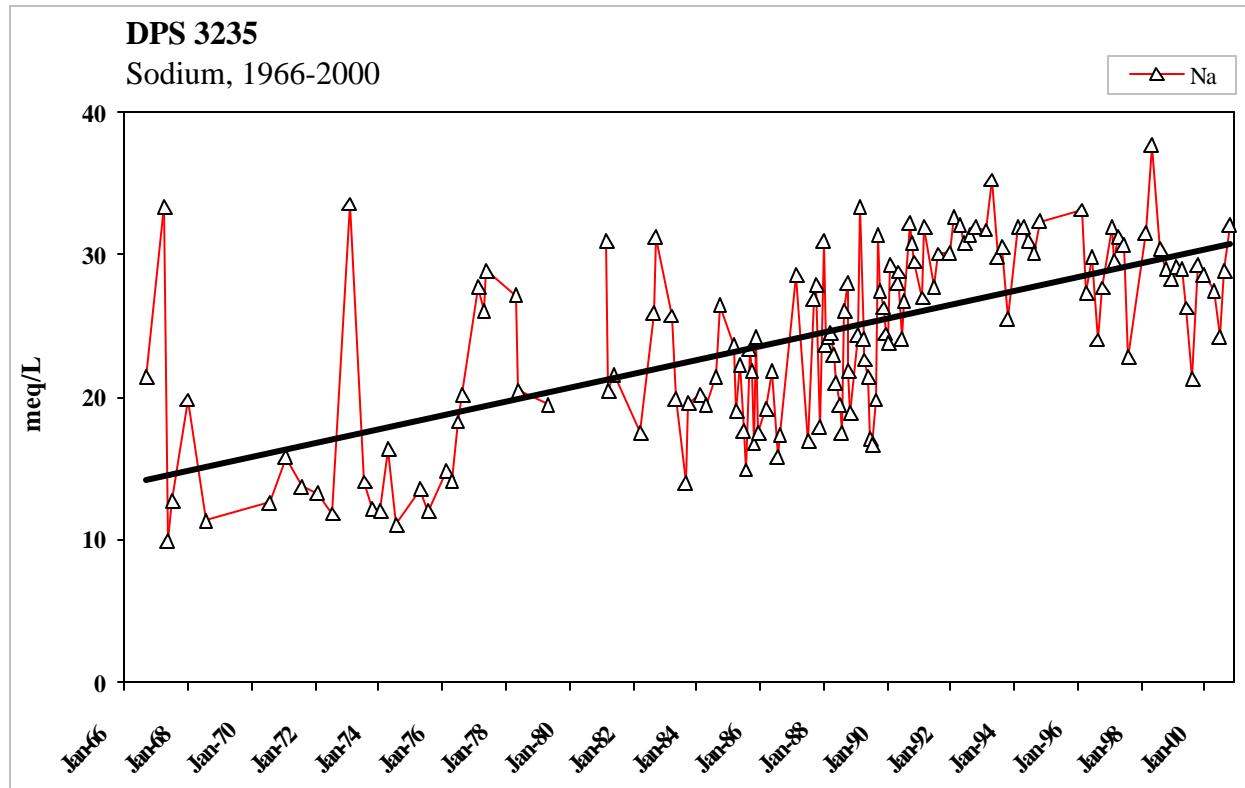
APPENDIX C



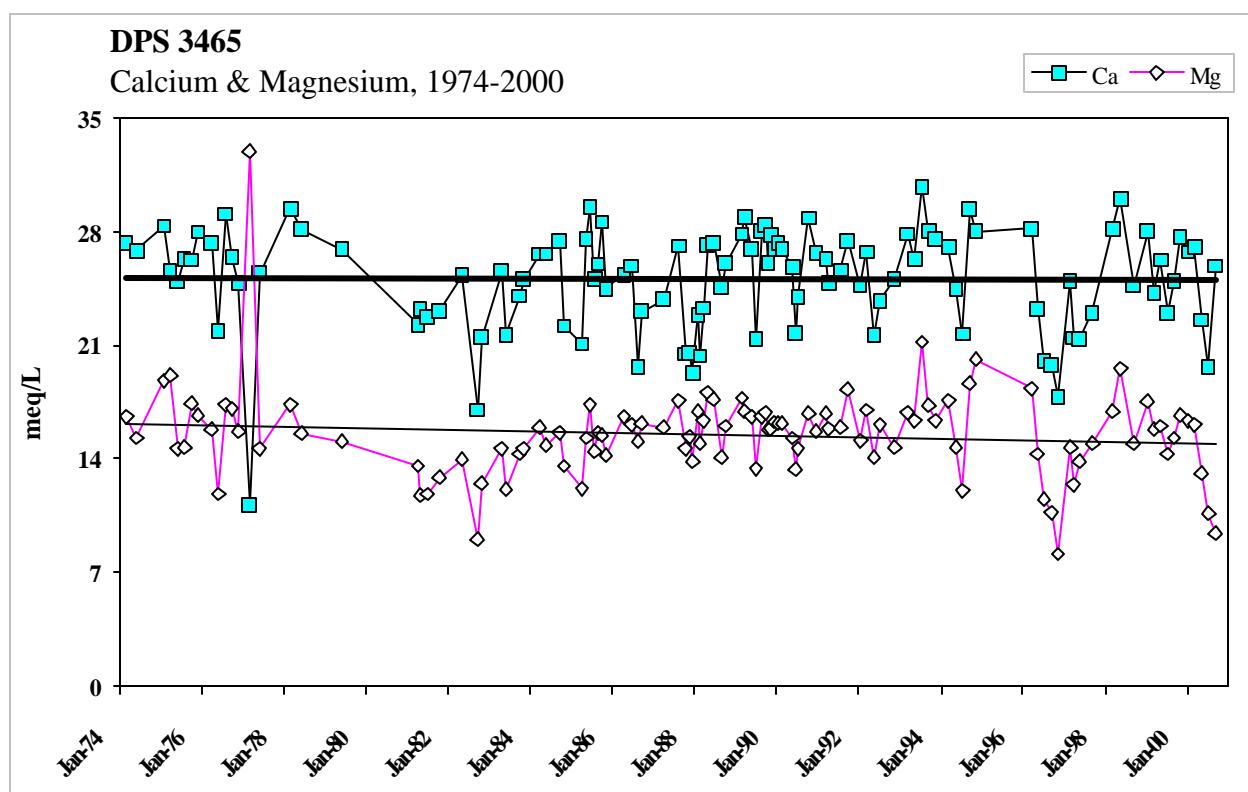
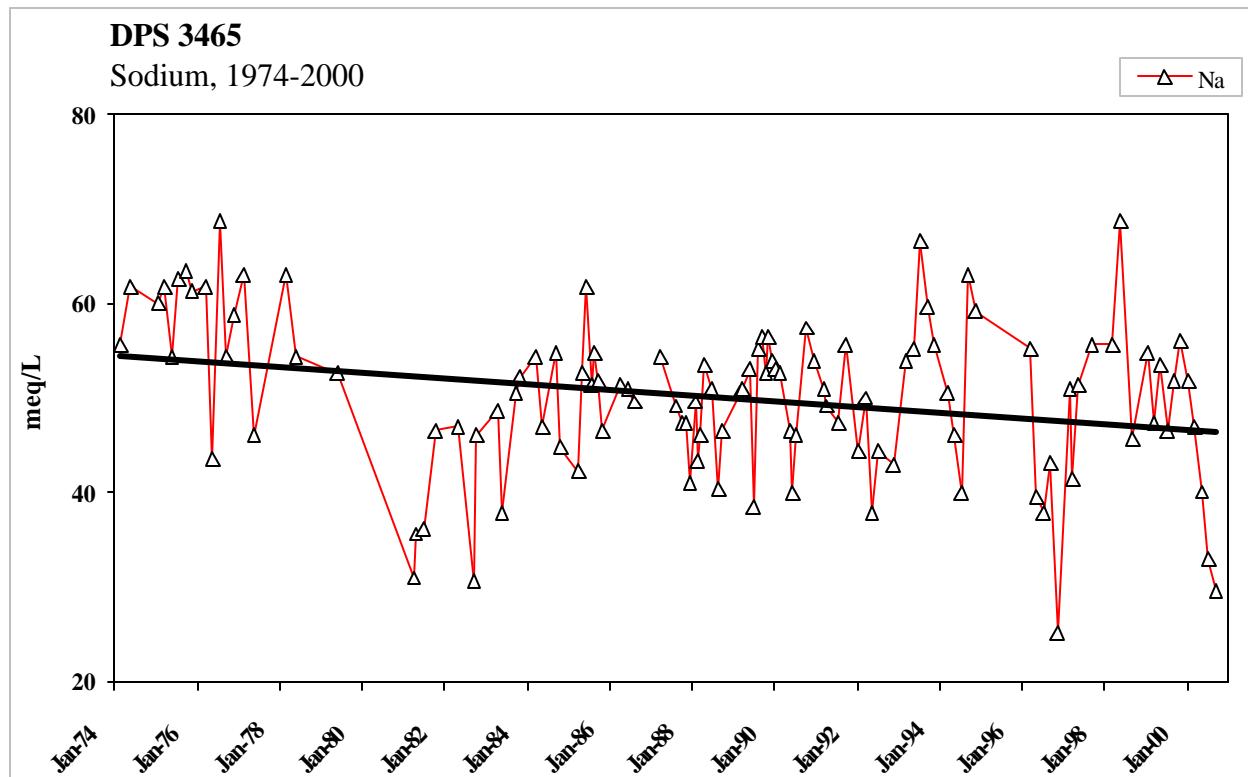
APPENDIX C



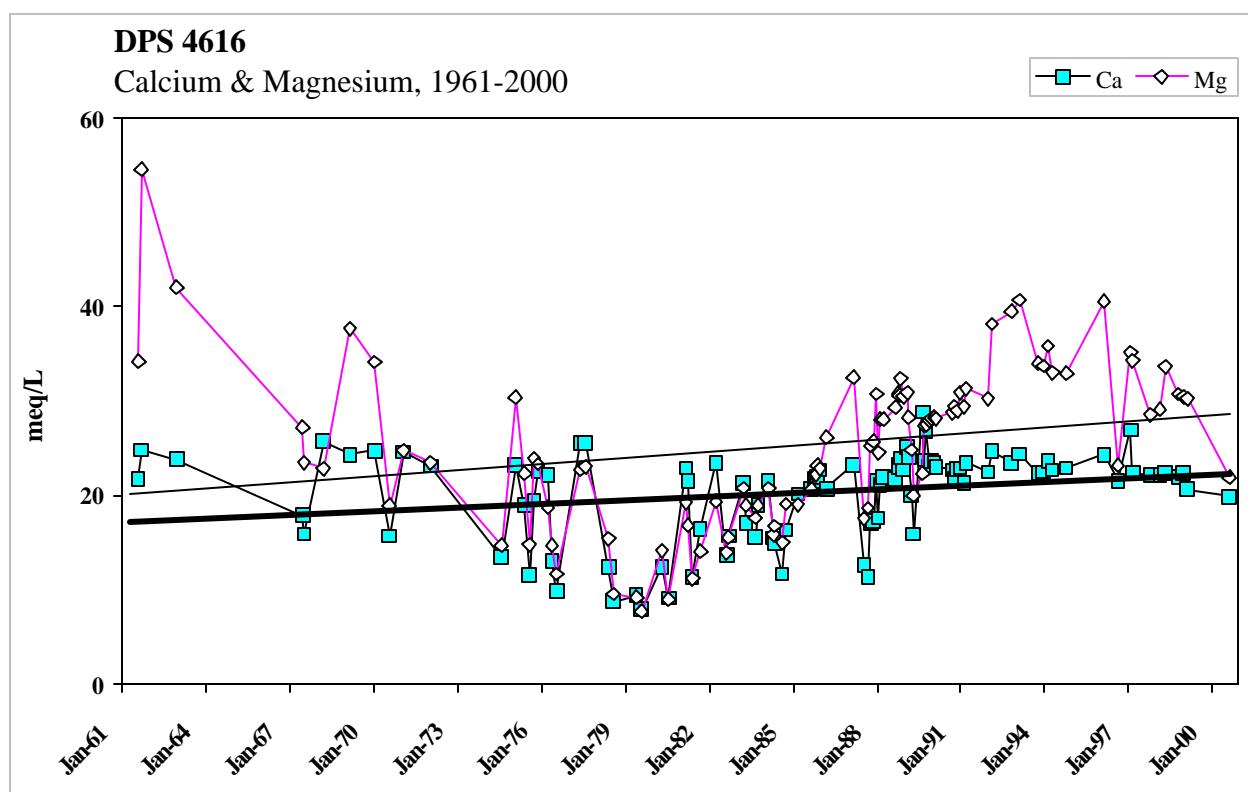
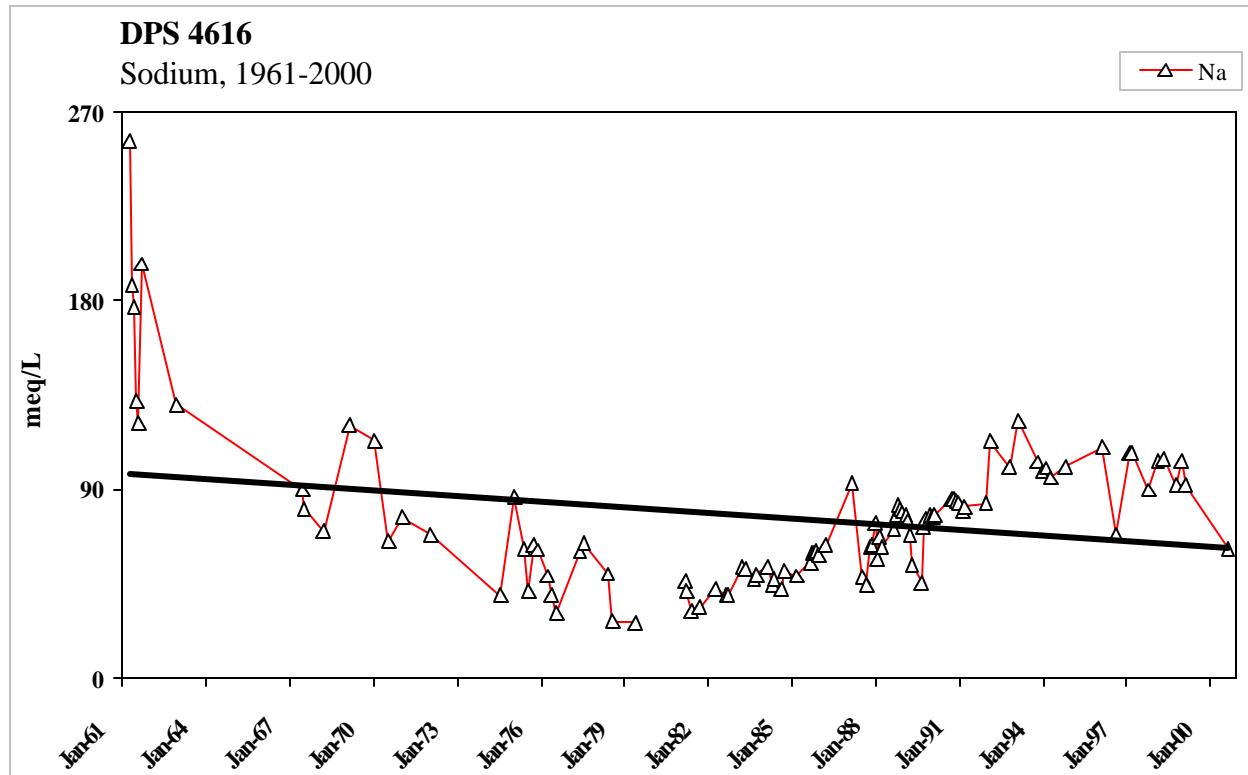
APPENDIX C



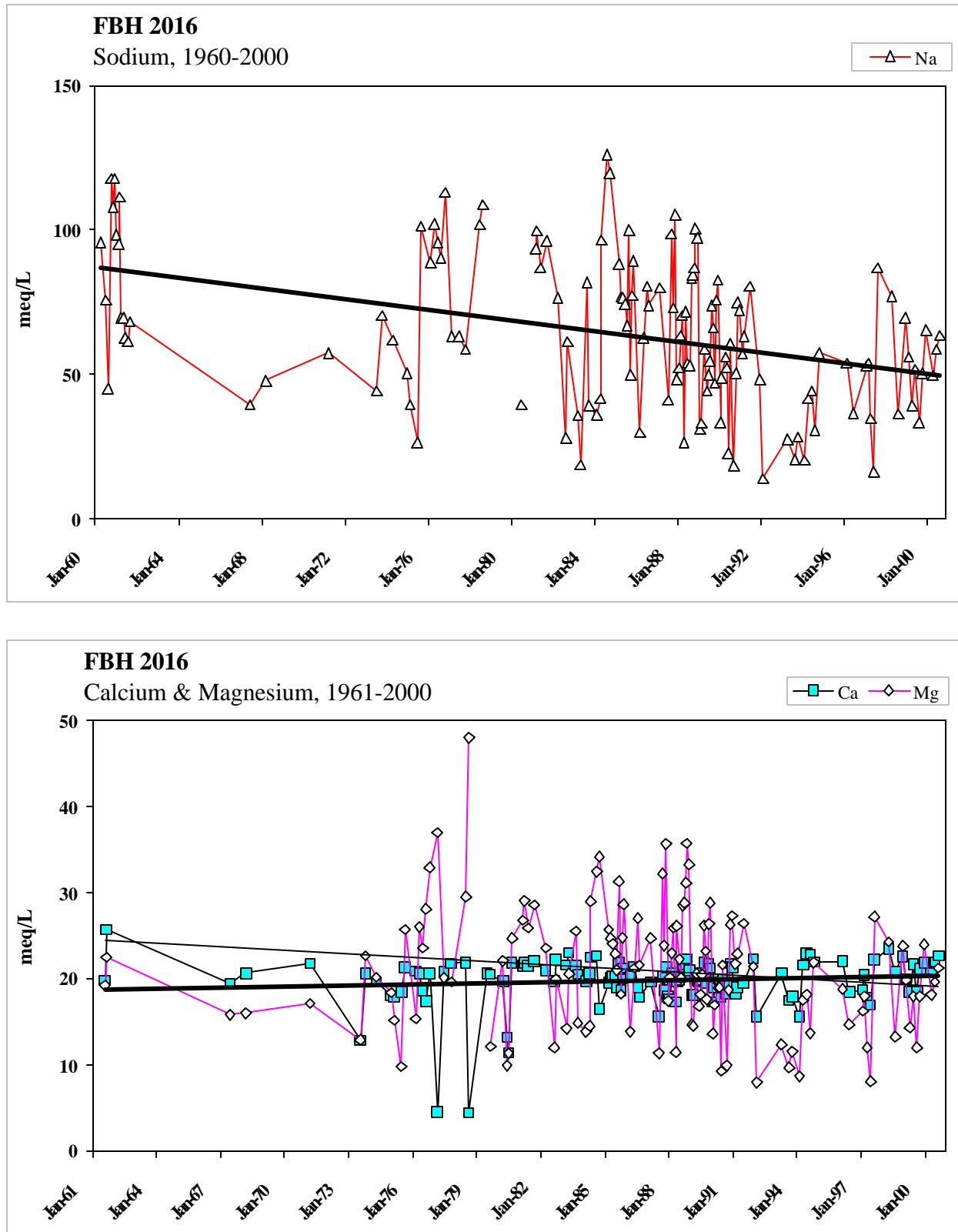
APPENDIX C



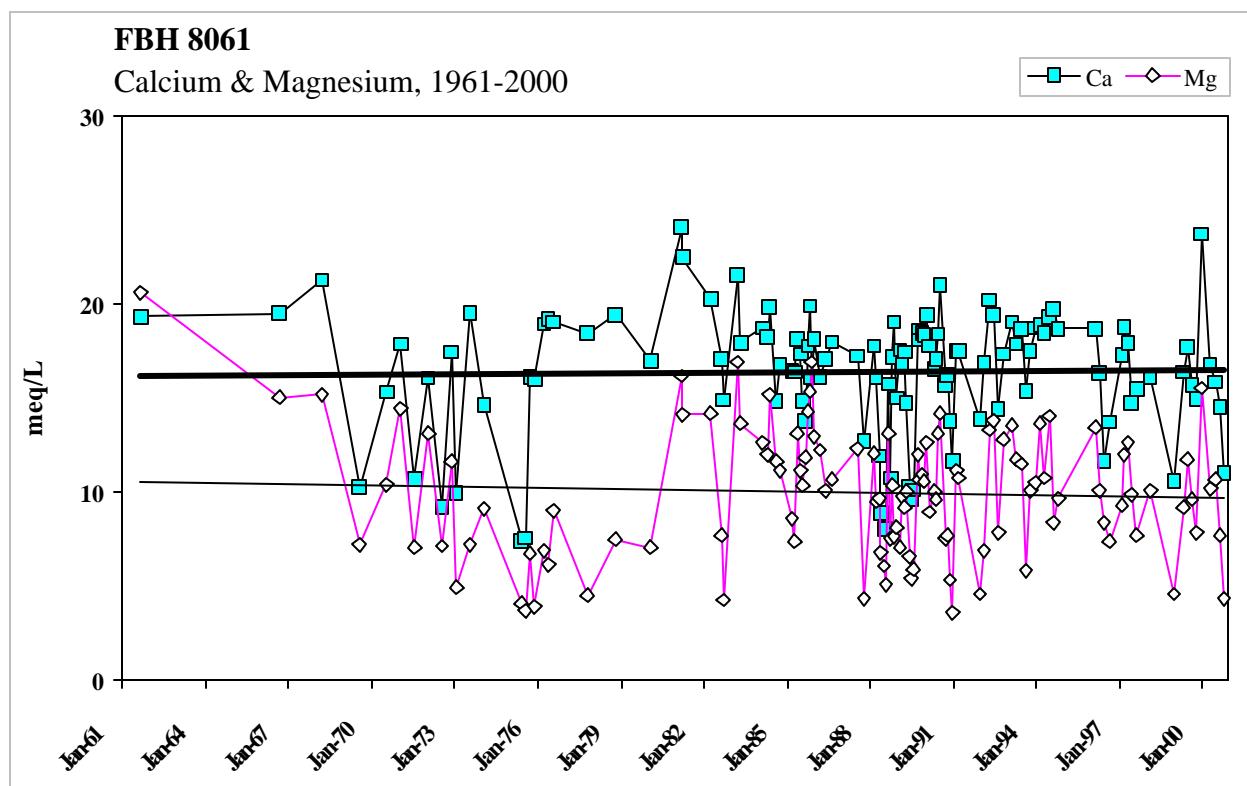
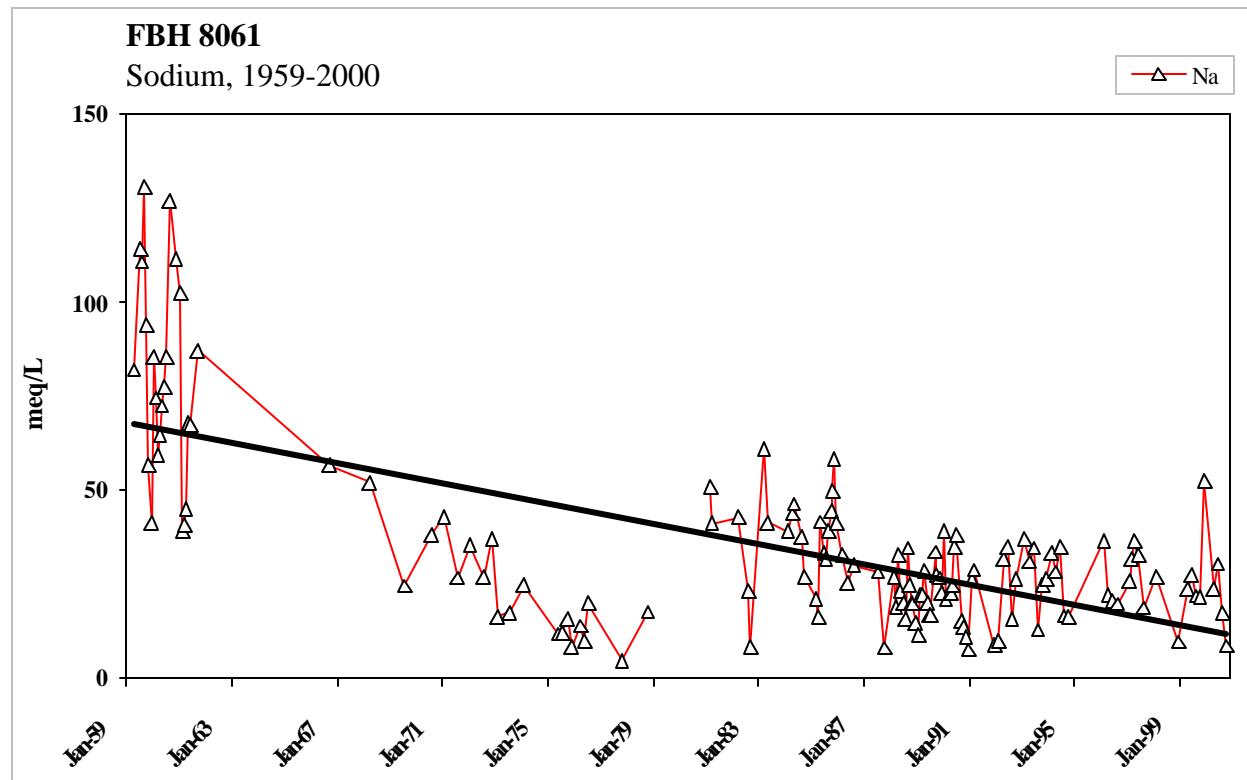
APPENDIX C



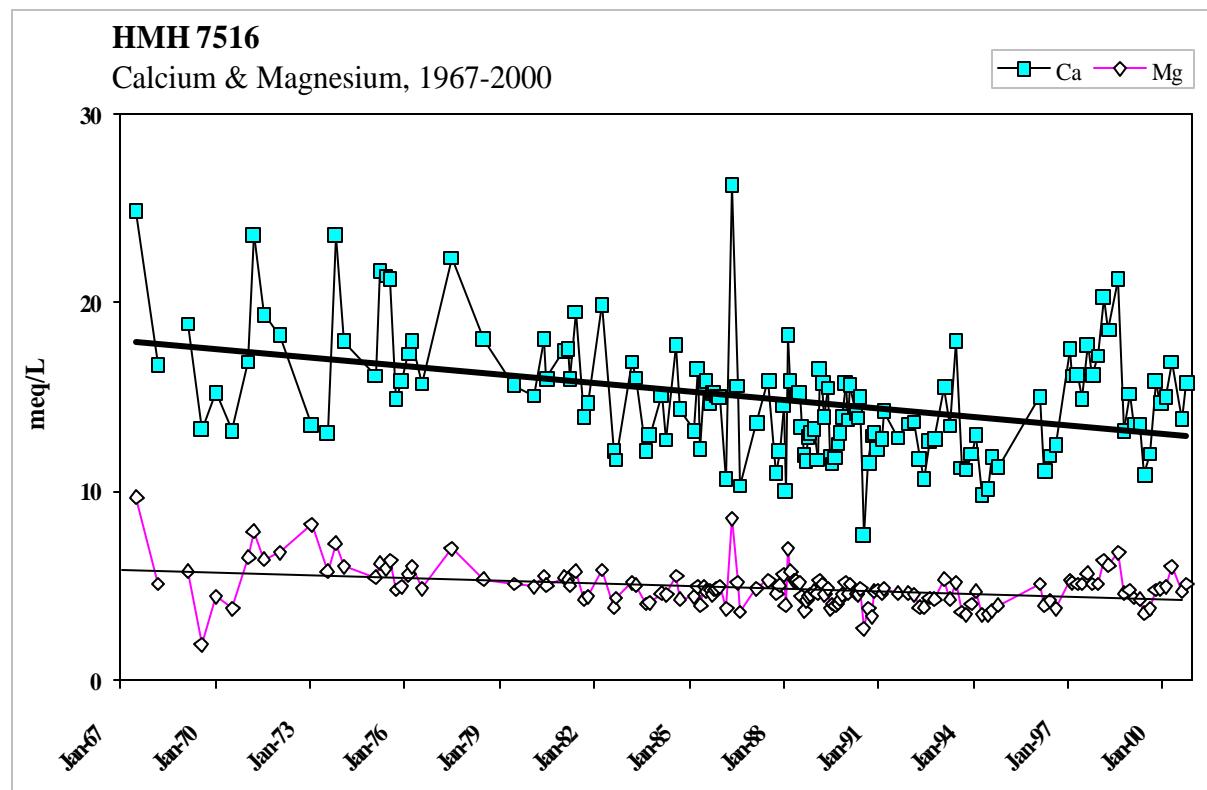
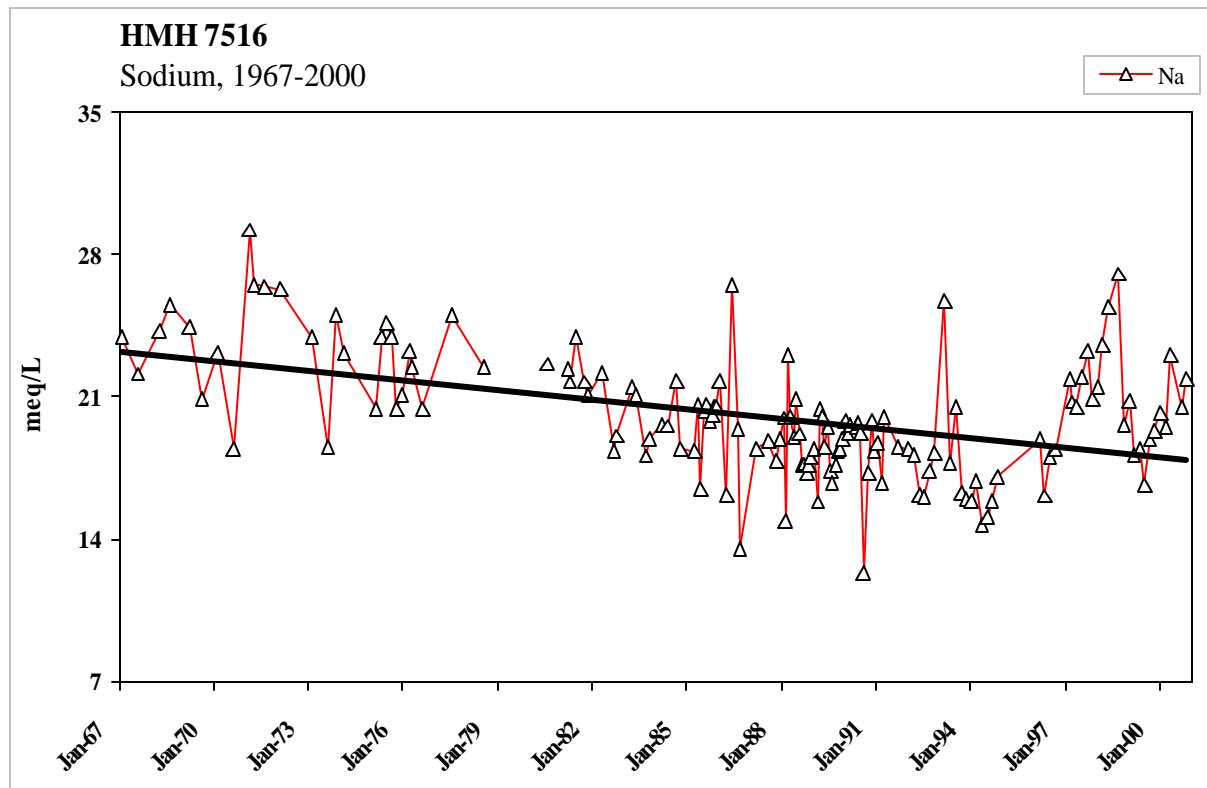
APPENDIX C



APPENDIX C



APPENDIX C



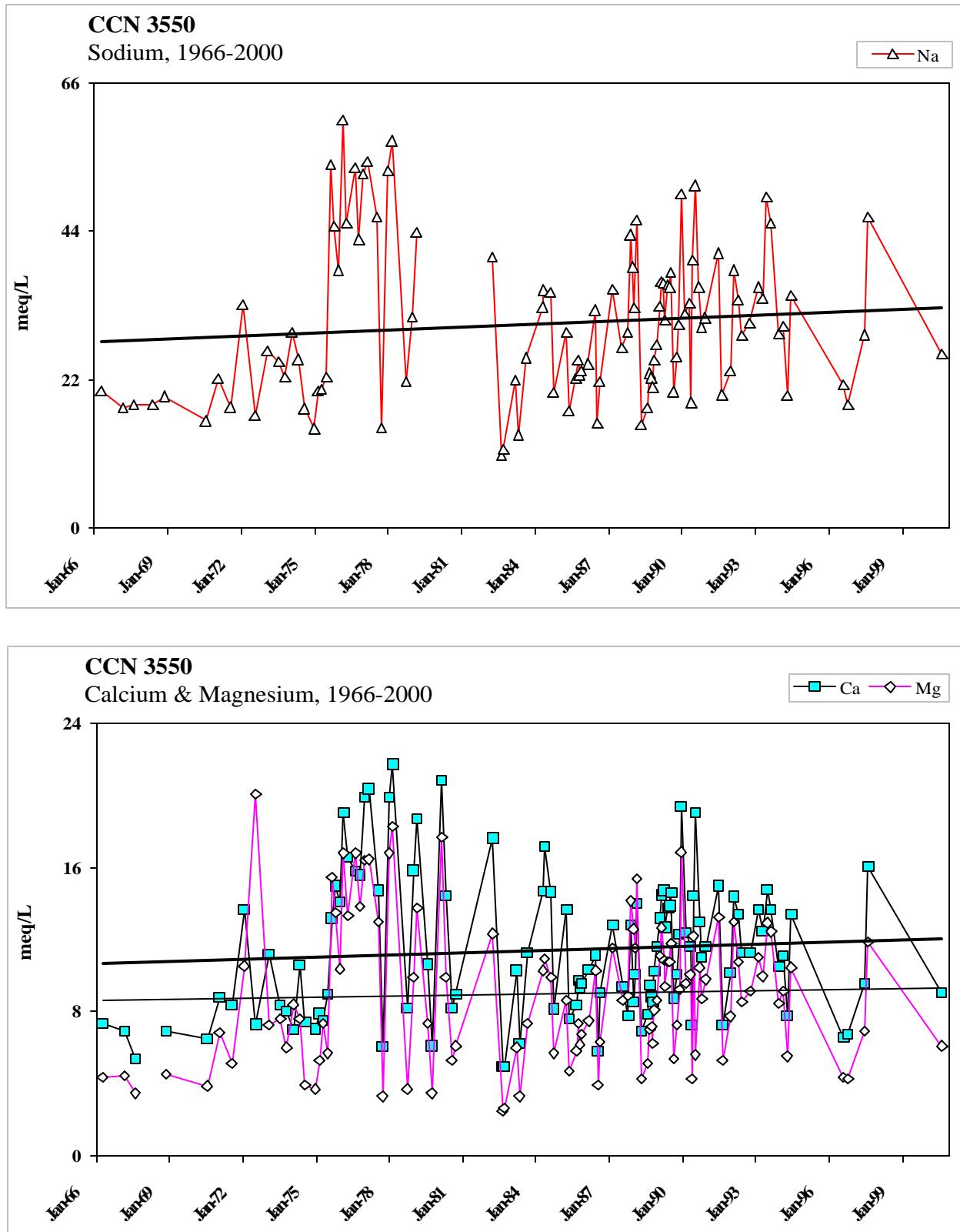
APPENDIX D

GRAPHS OF WATER QUALITY CATION TRENDS IN DRAINAGE SUMPS

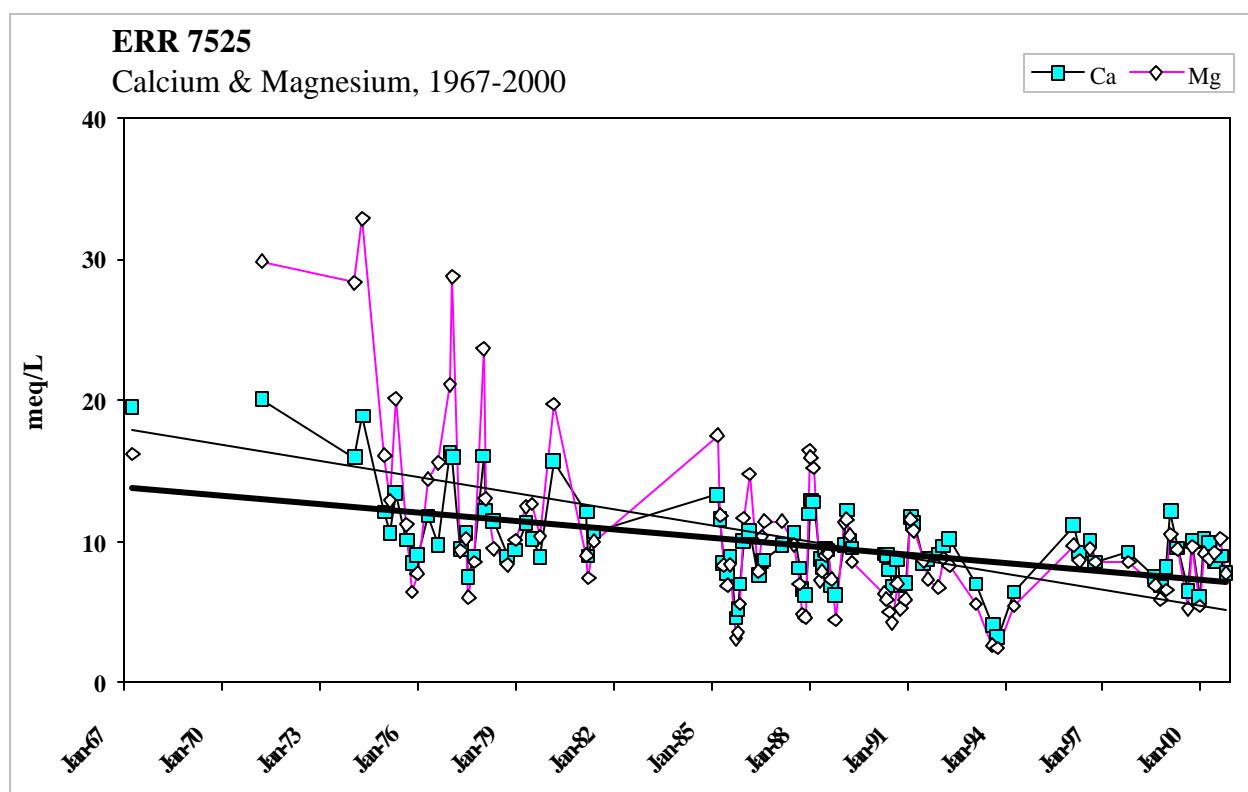
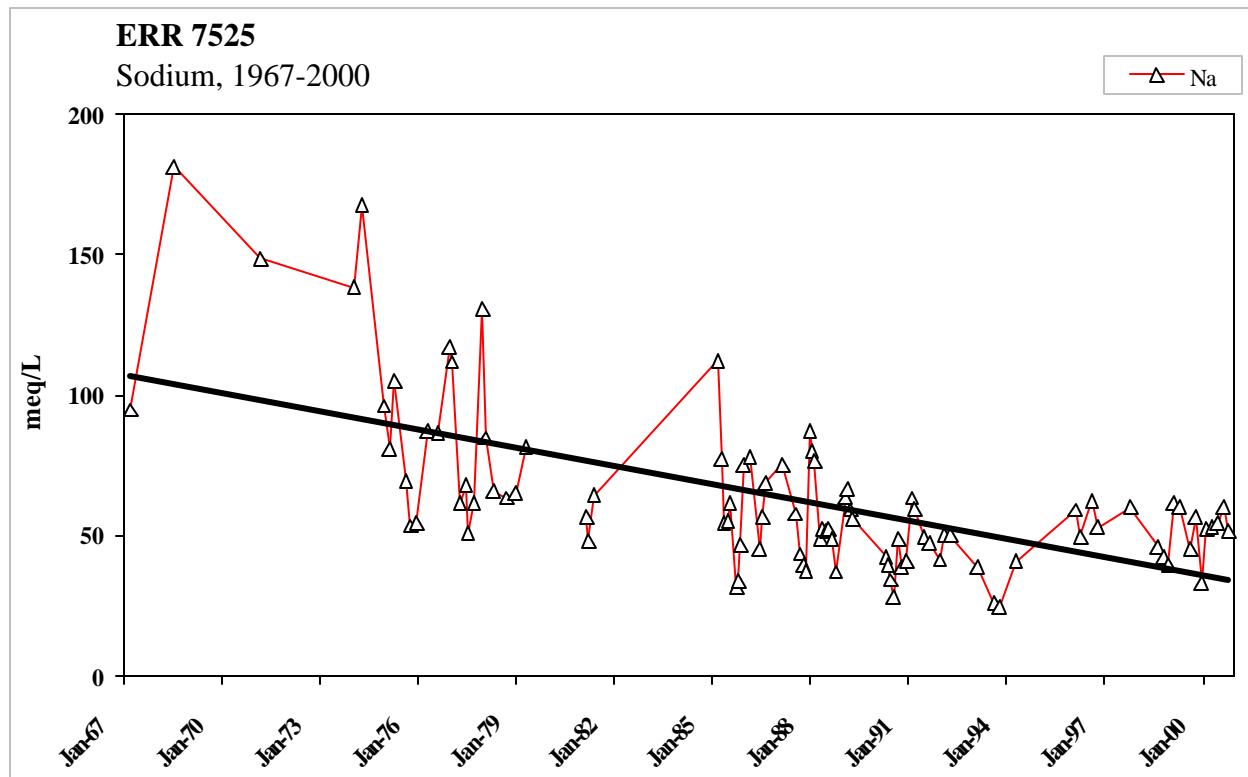
SOUTHERN AREA

LEMOORE-CORCORAN STATIONS

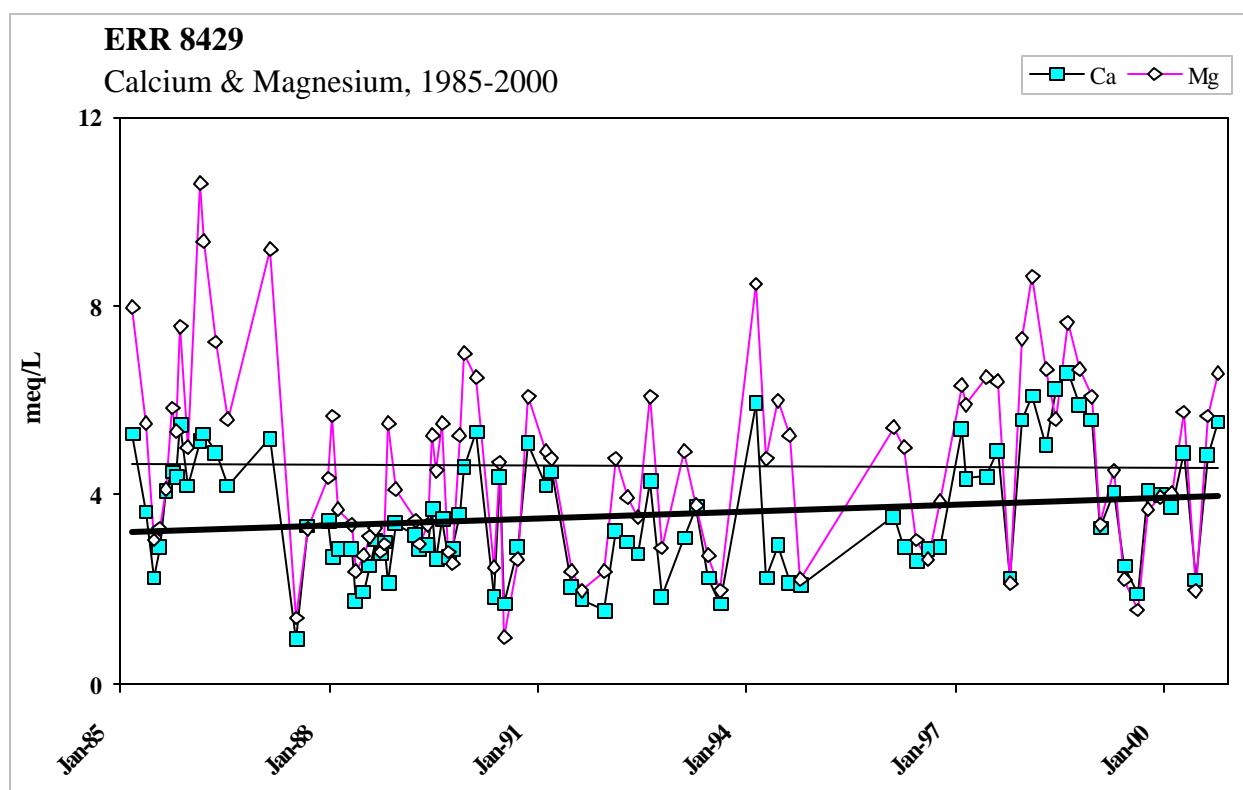
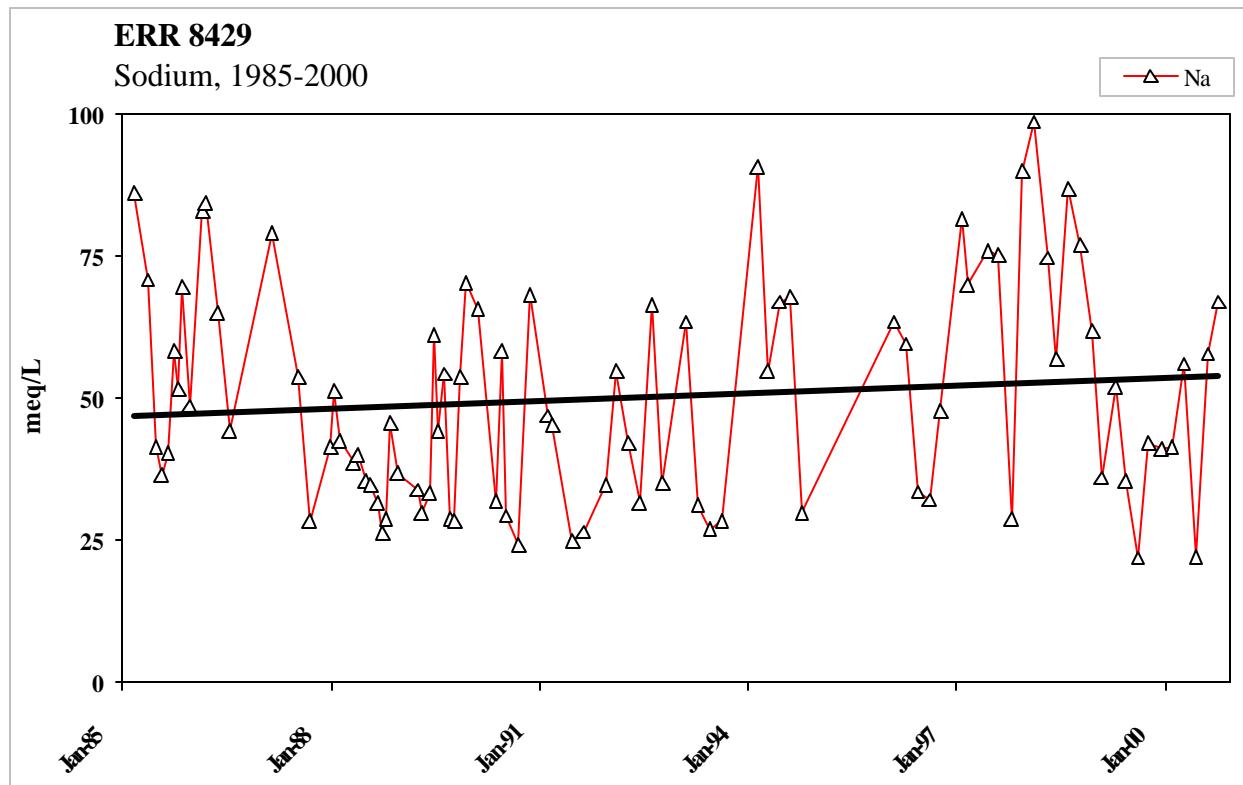
APPENDIX D



APPENDIX D



APPENDIX D

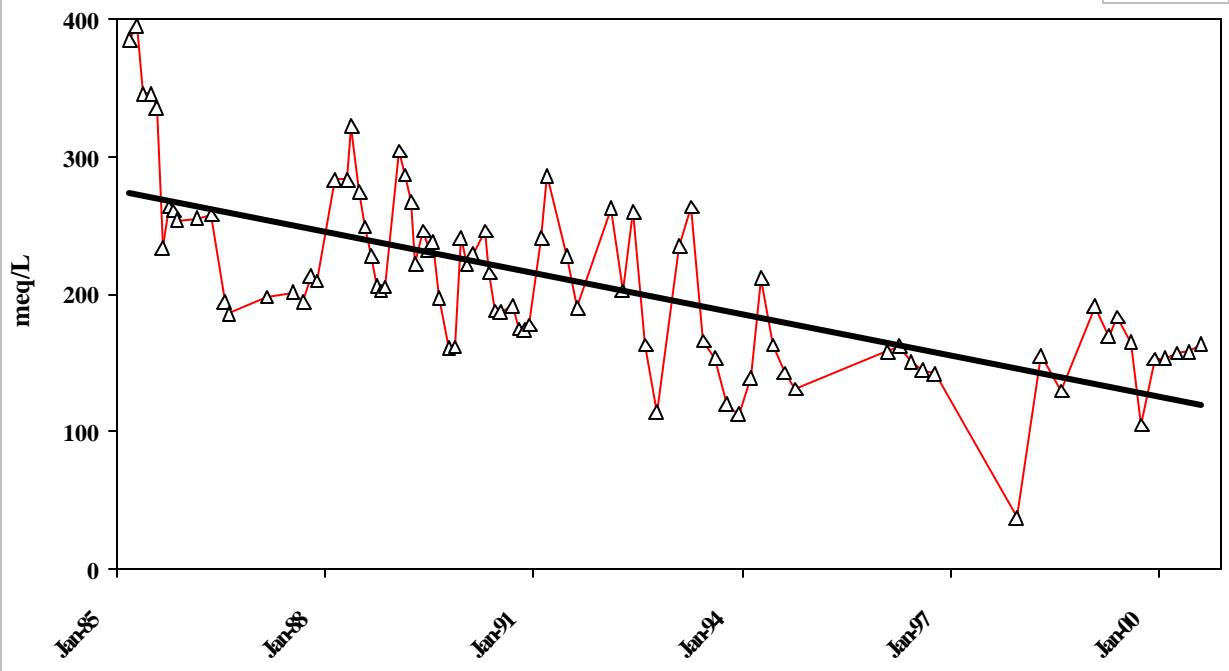


APPENDIX D

ERR 8641

Sodium, 1985-2000

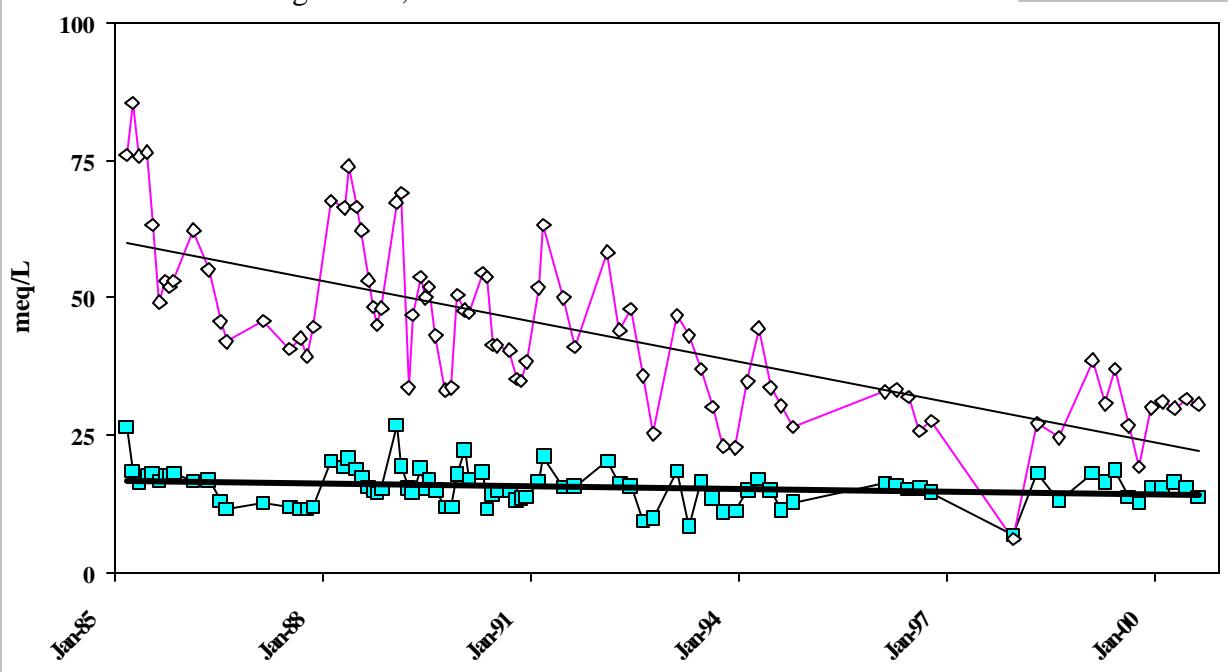
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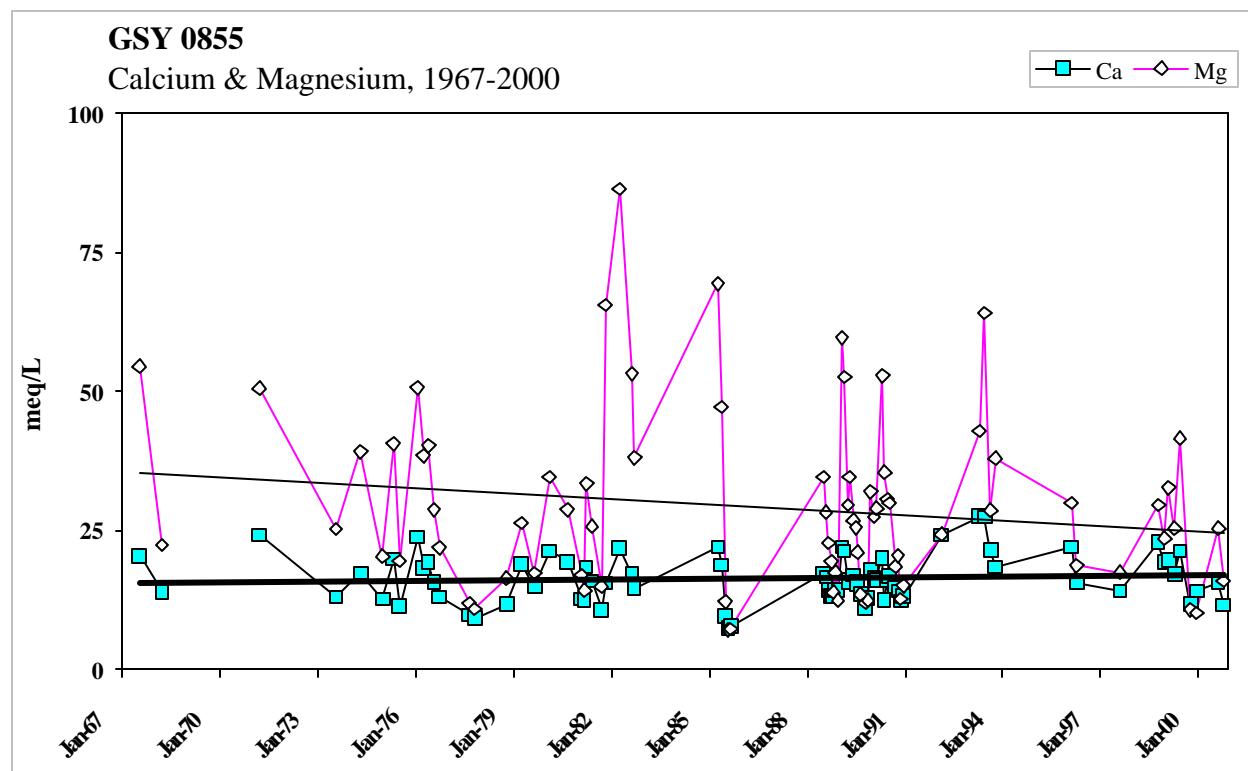
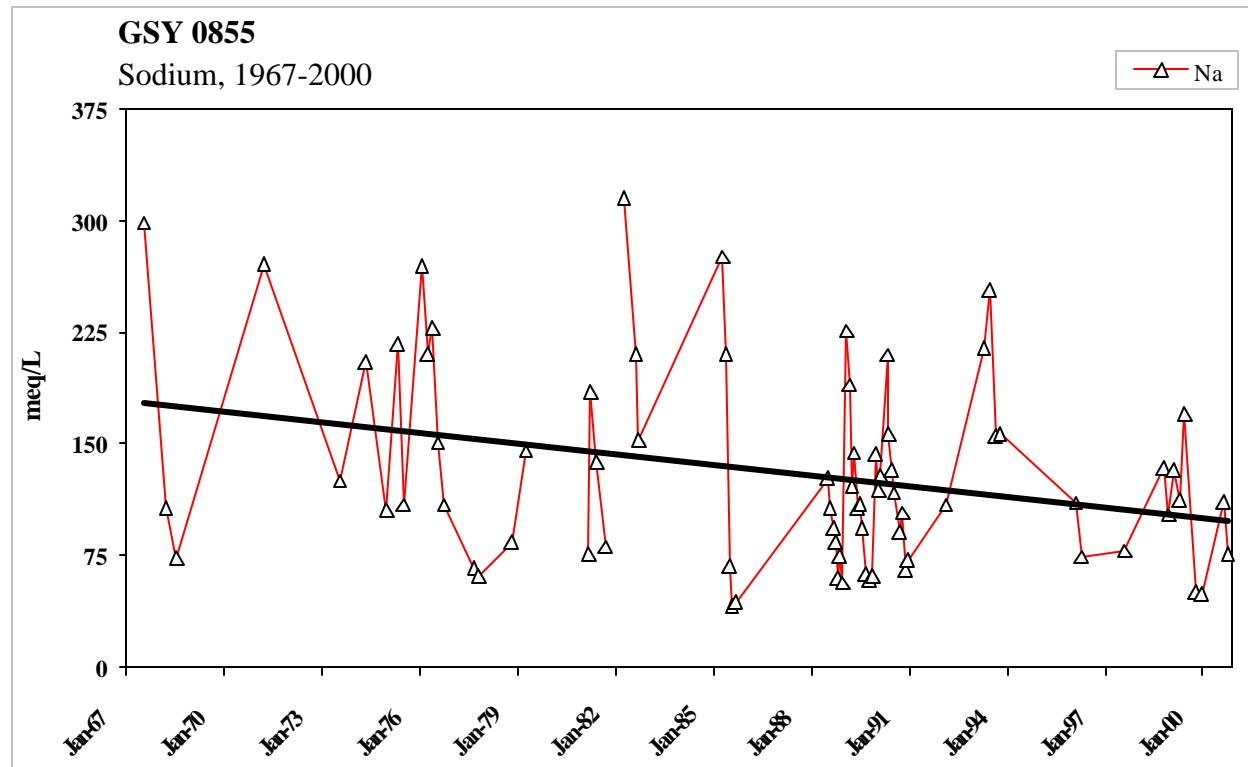
ERR 8641

Calcium & Magnesium, 1985-2000

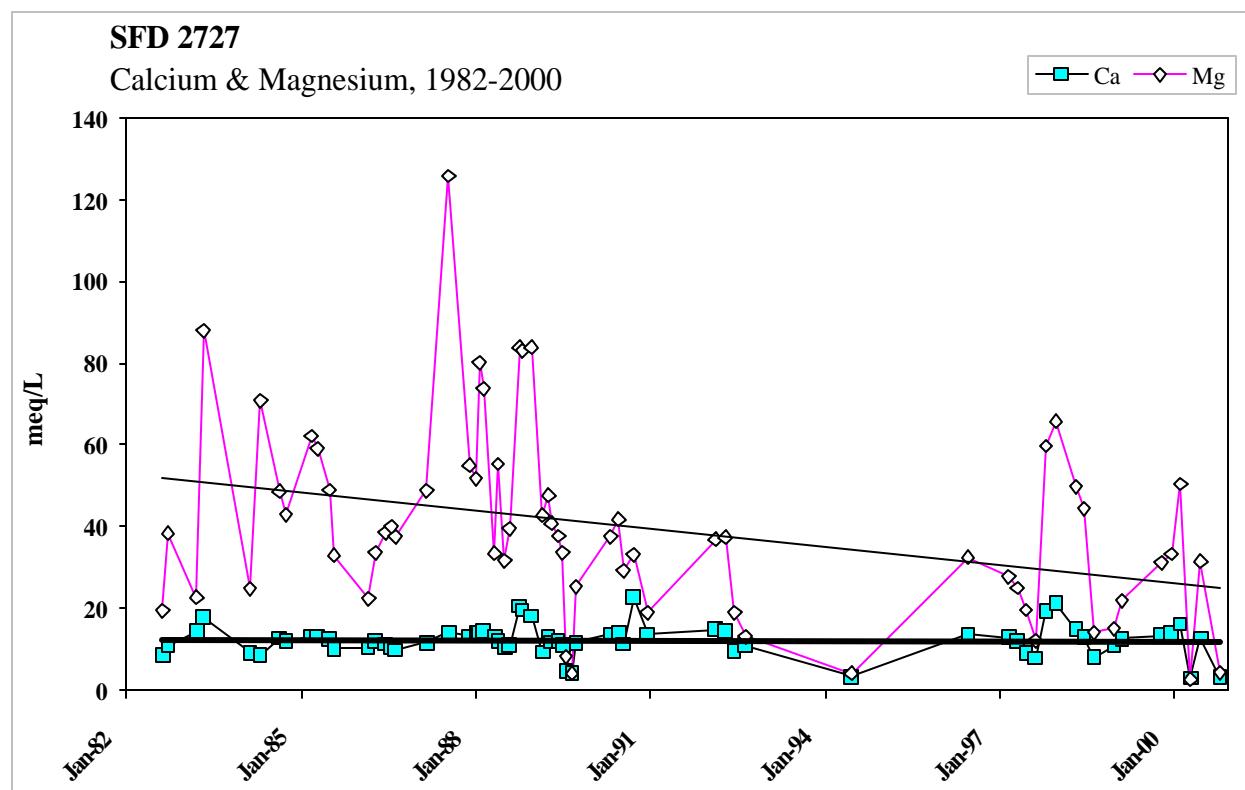
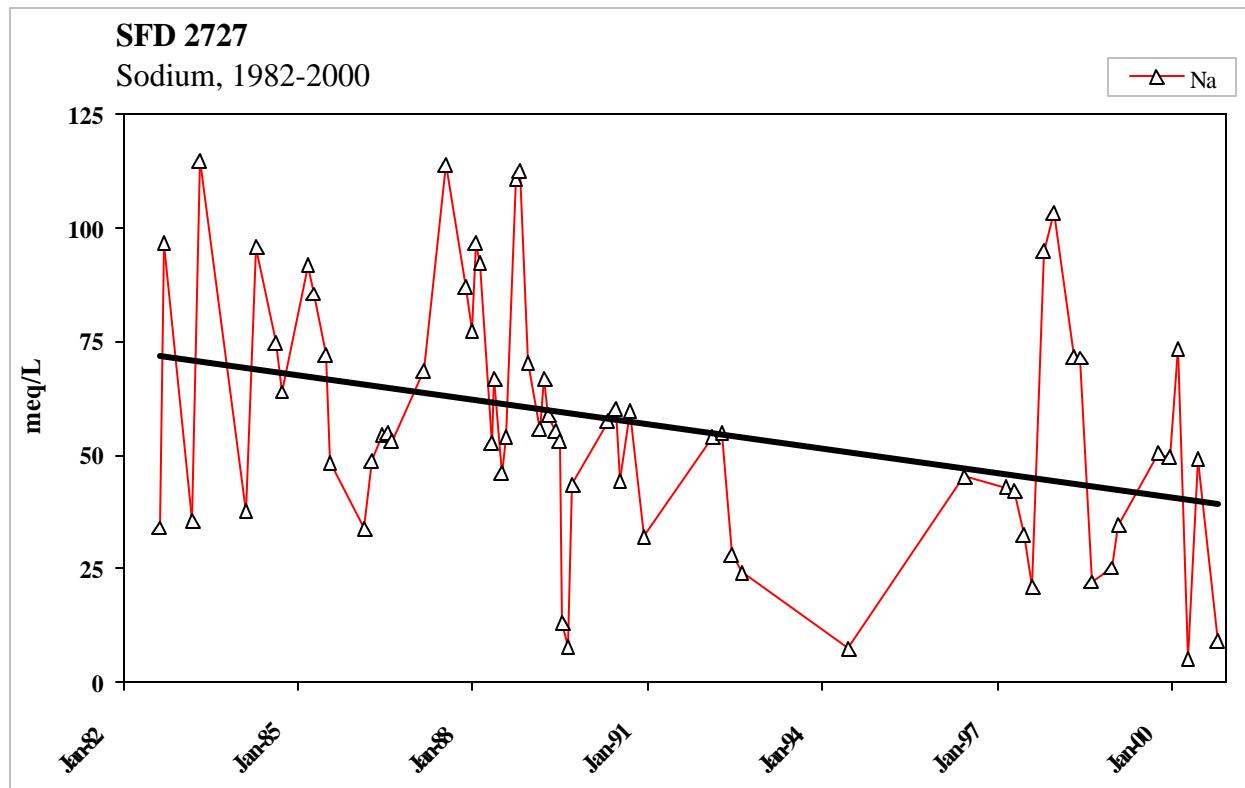
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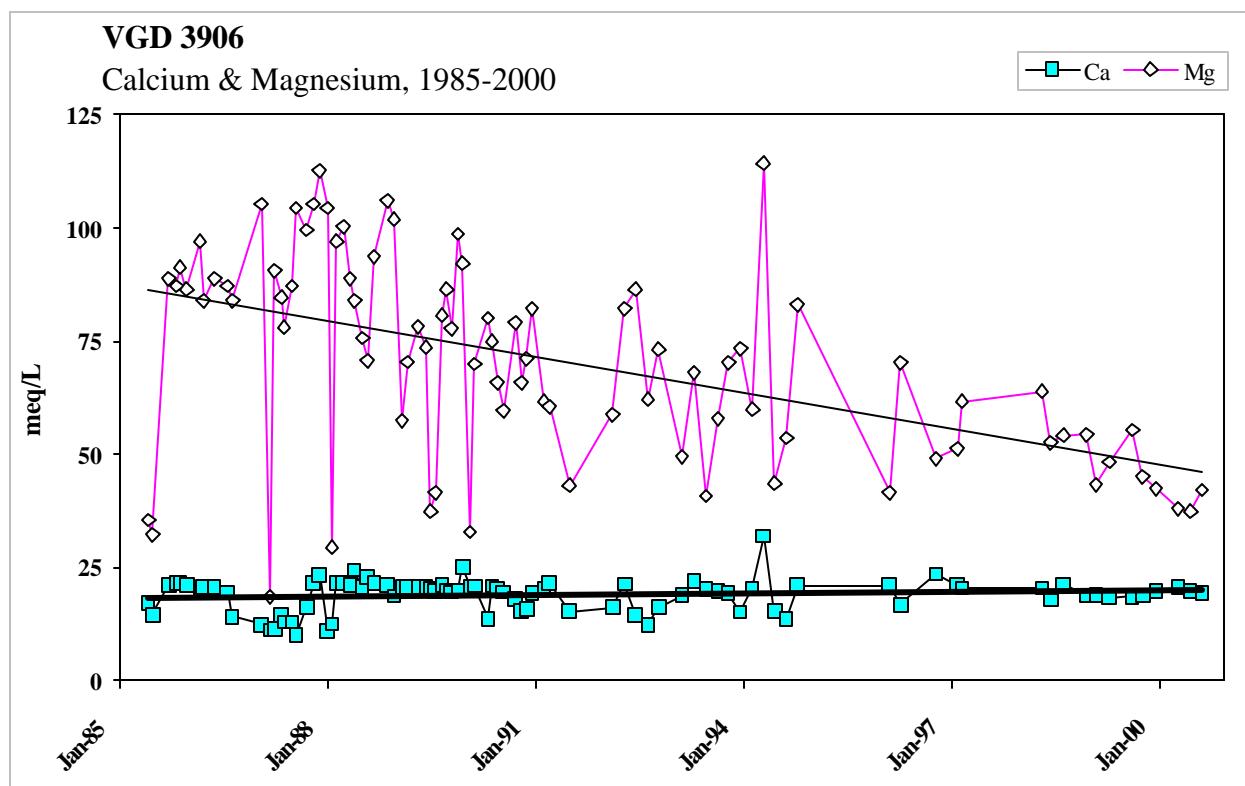
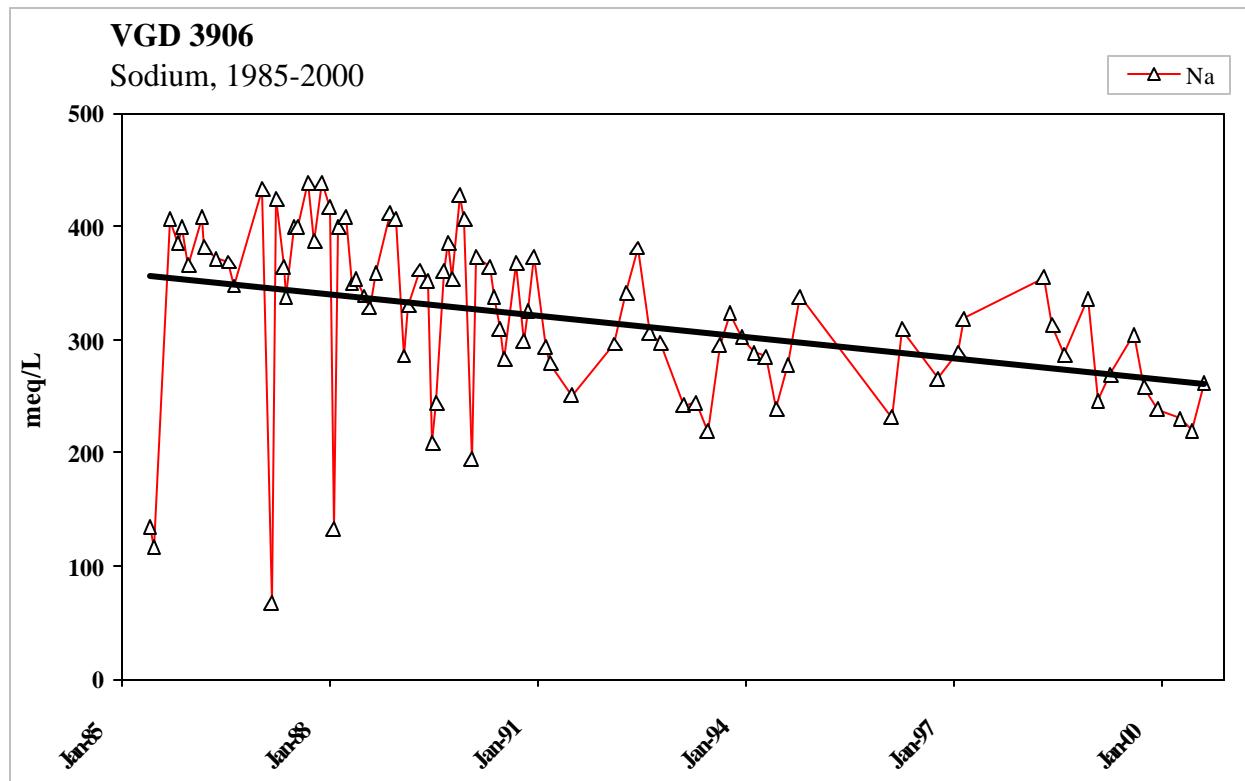
APPENDIX D



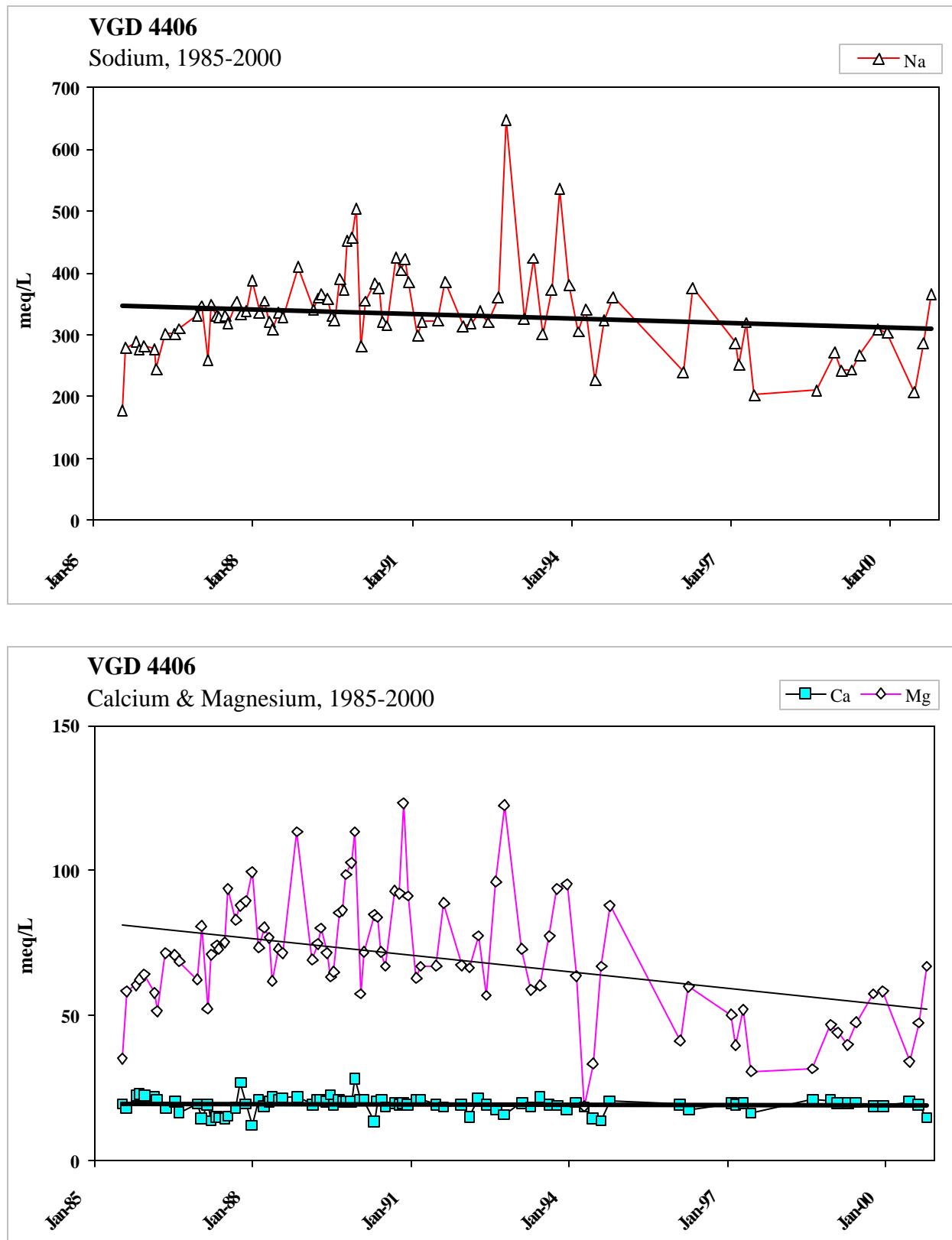
APPENDIX D



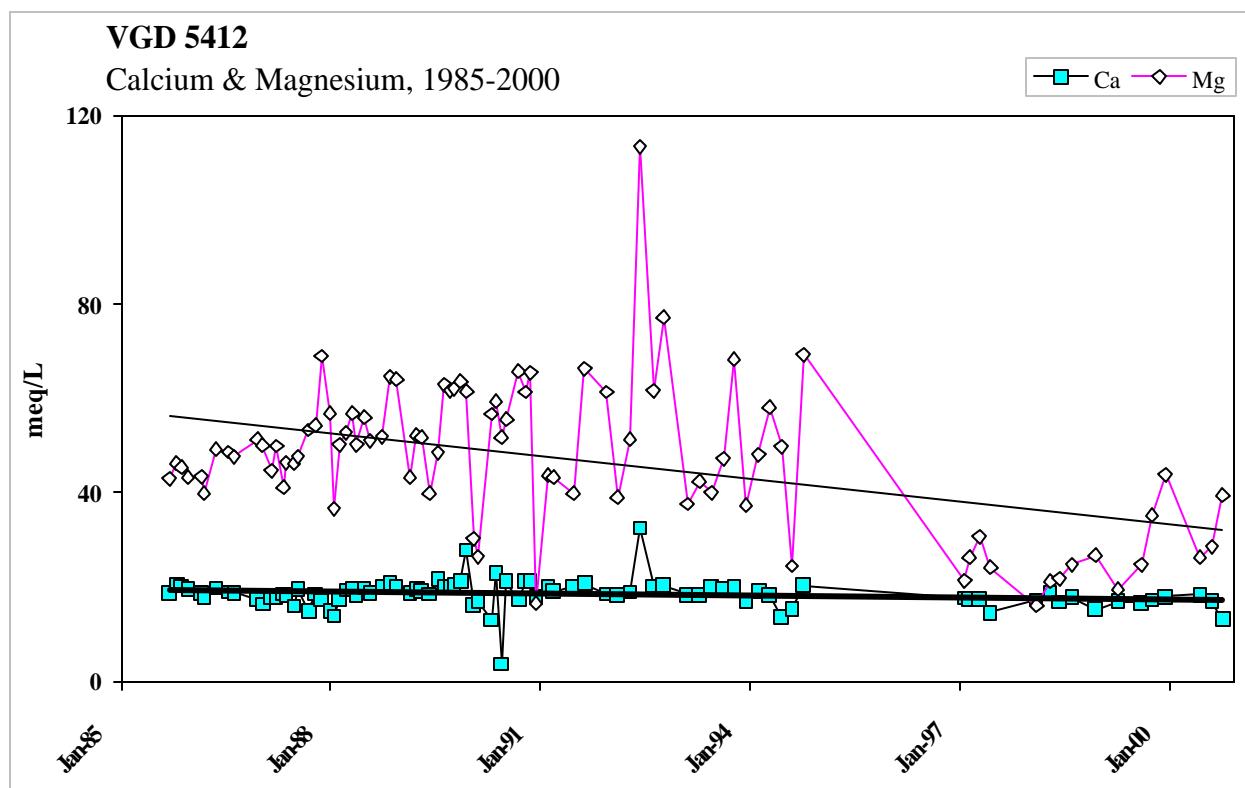
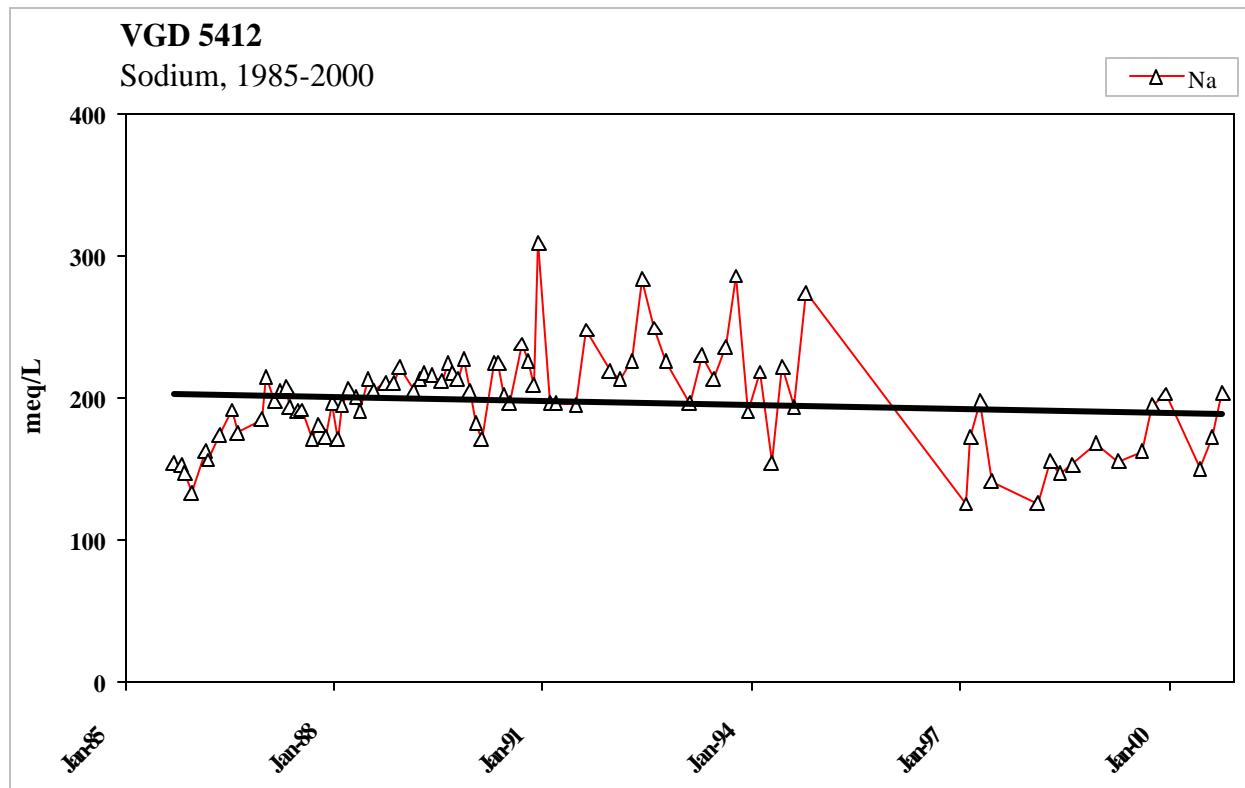
APPENDIX D



APPENDIX D



APPENDIX D



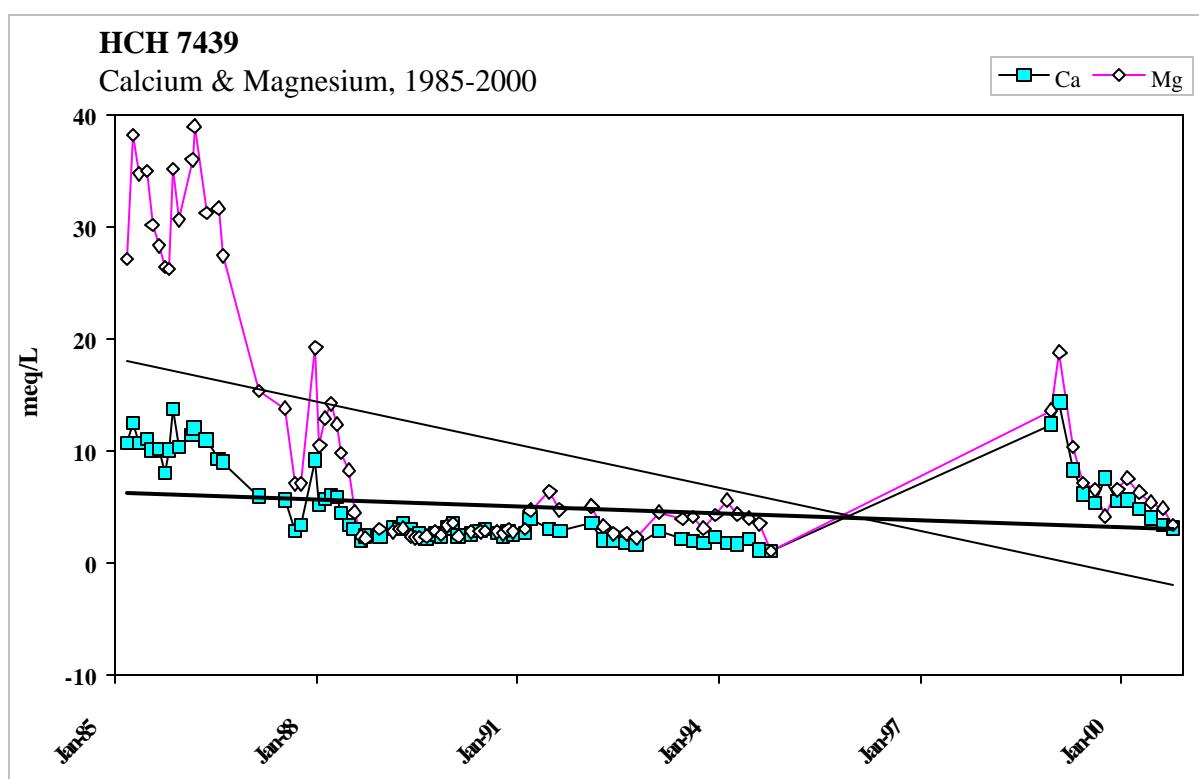
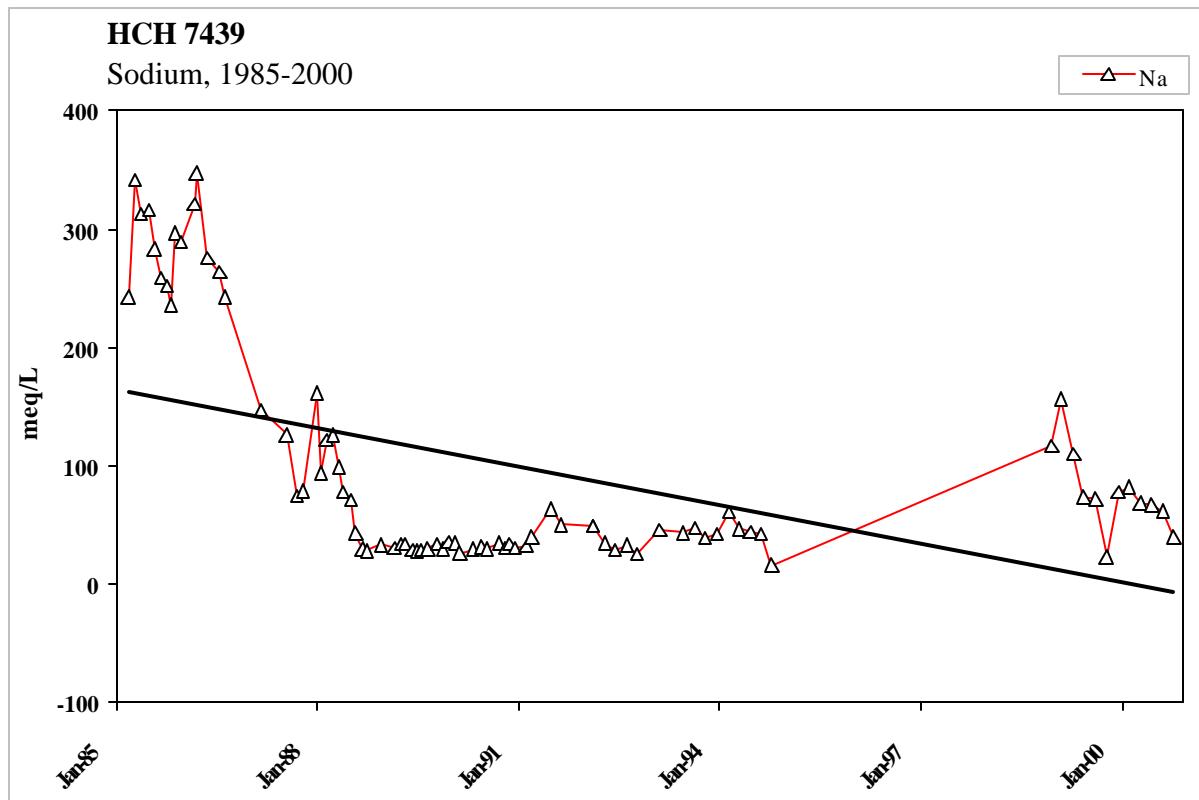
APPENDIX D

GRAPHS OF WATER QUALITY CATION TRENDS IN DRAINAGE SUMPS

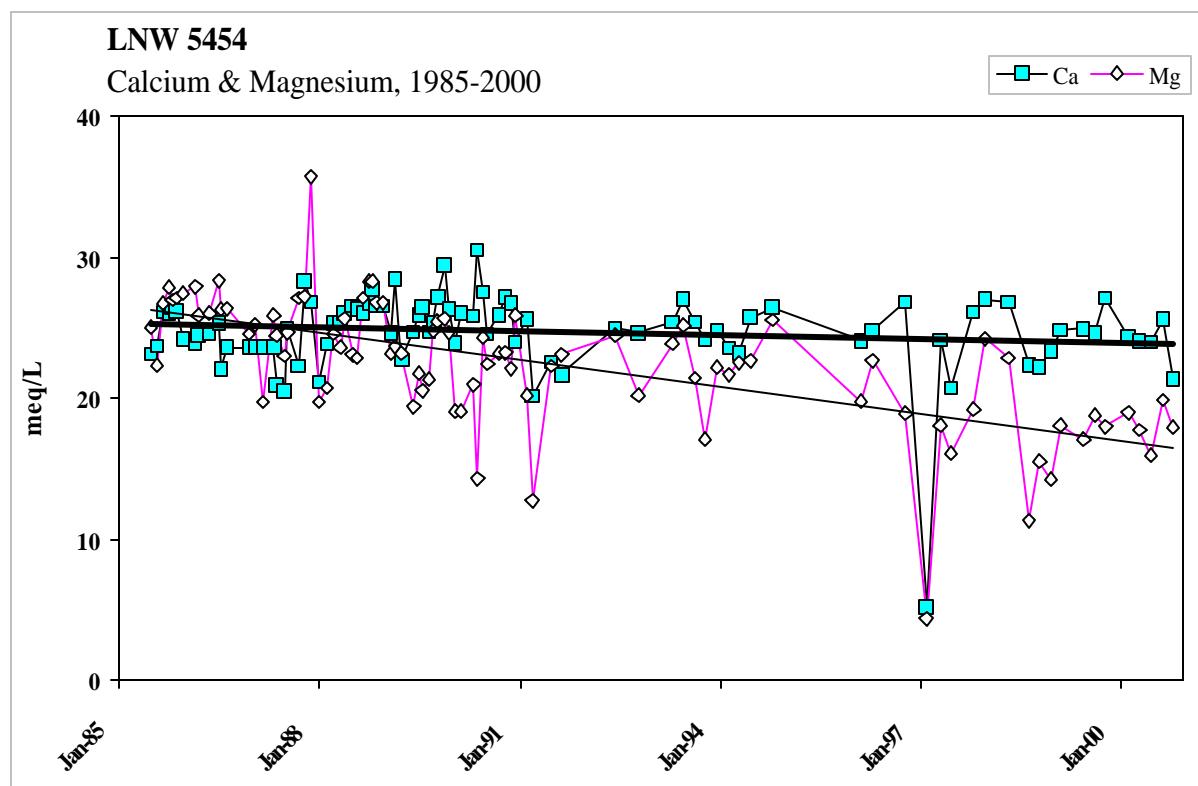
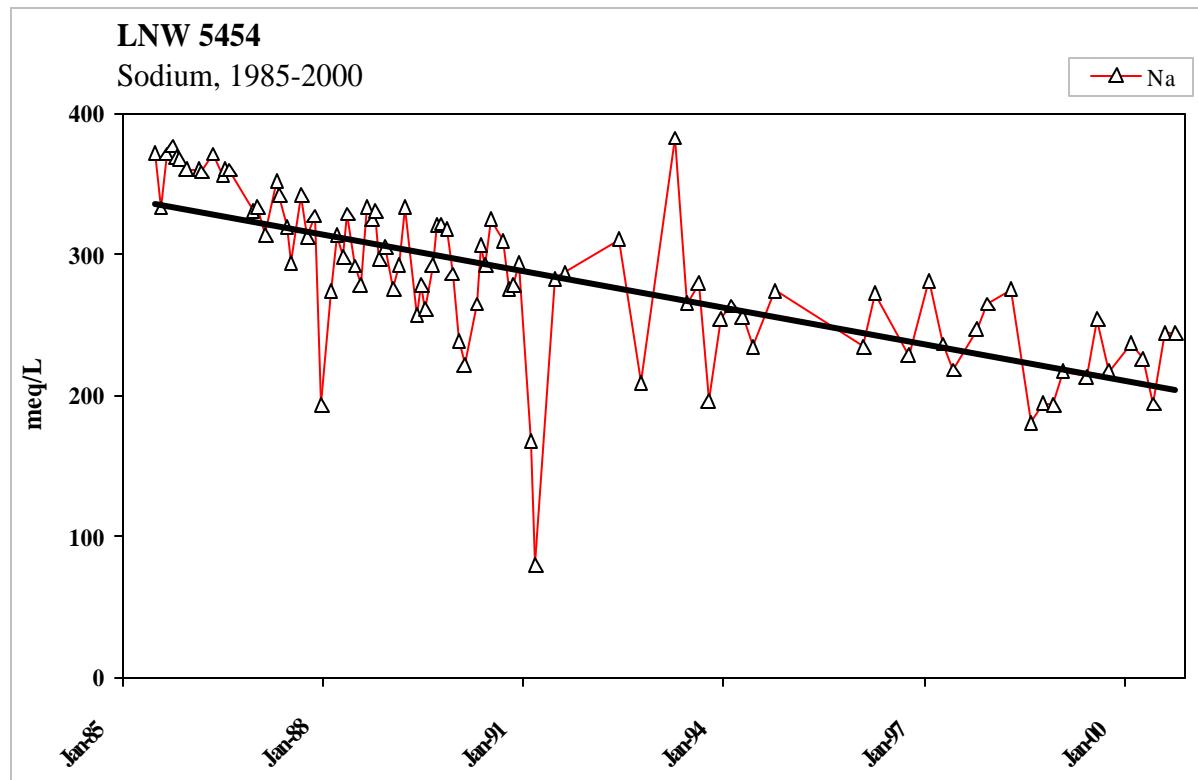
SOUTHERN AREA

LOST HILLS-SEMITROPIC STATIONS

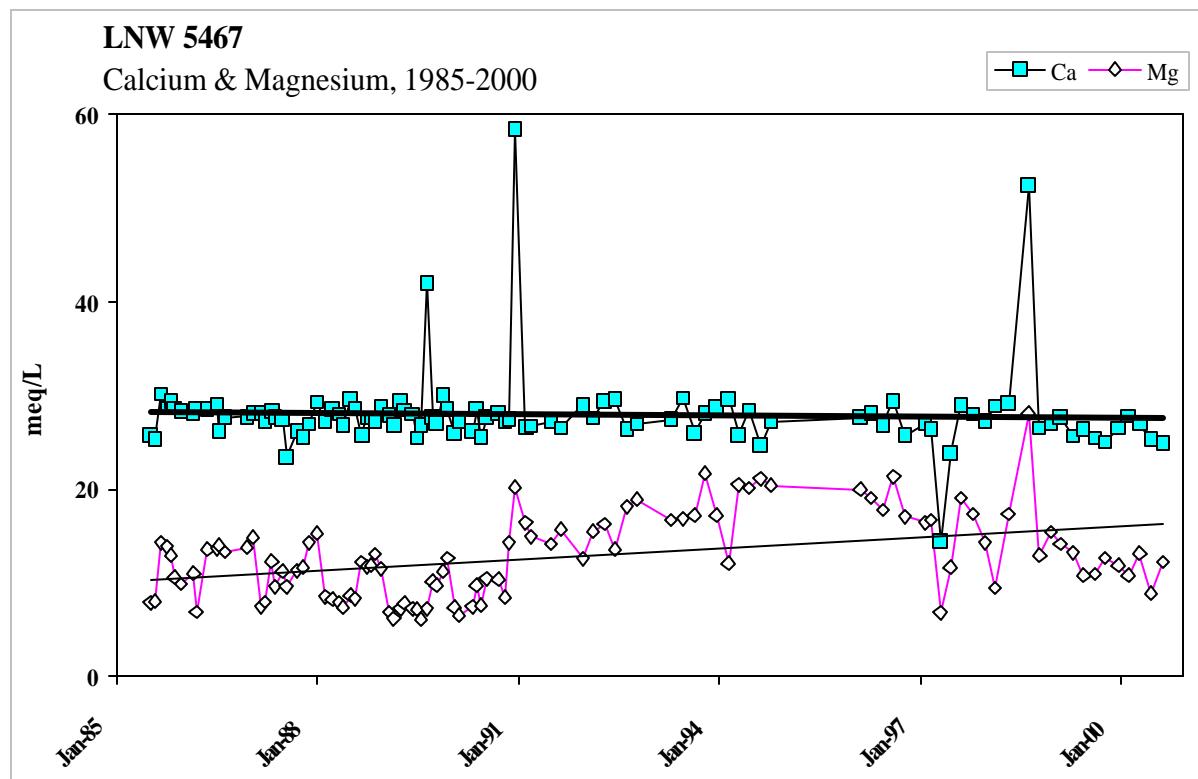
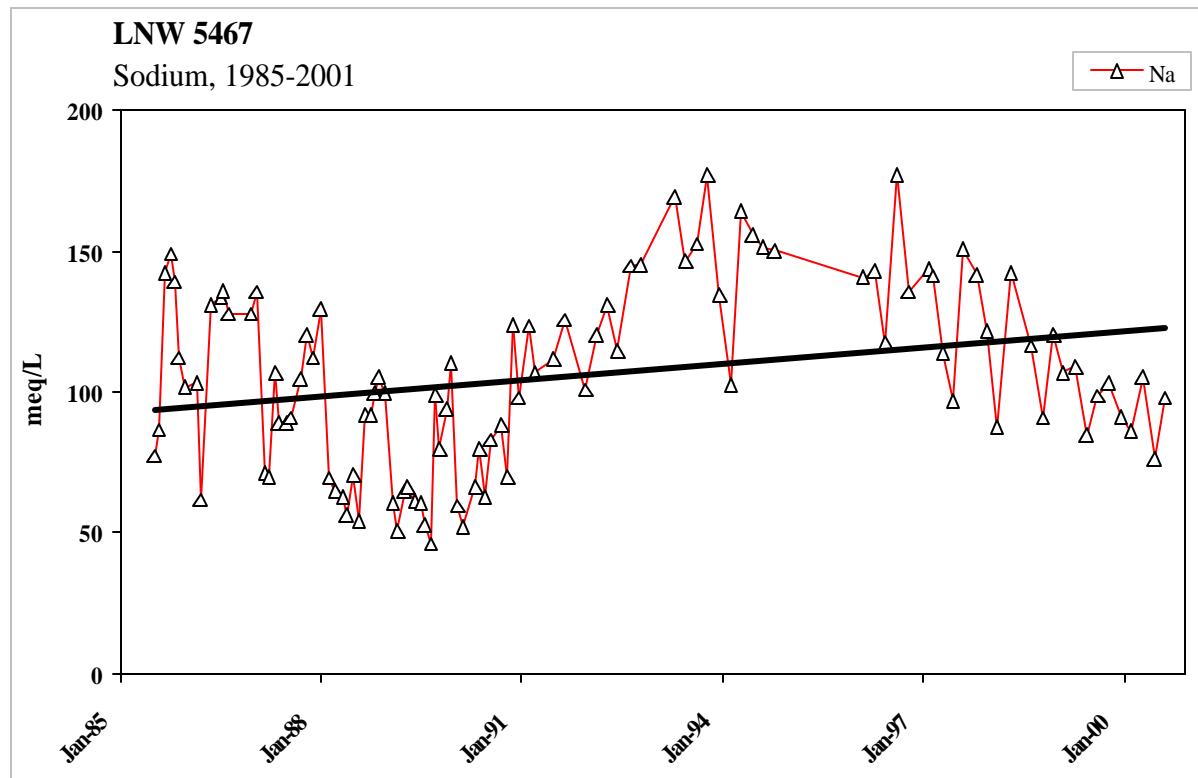
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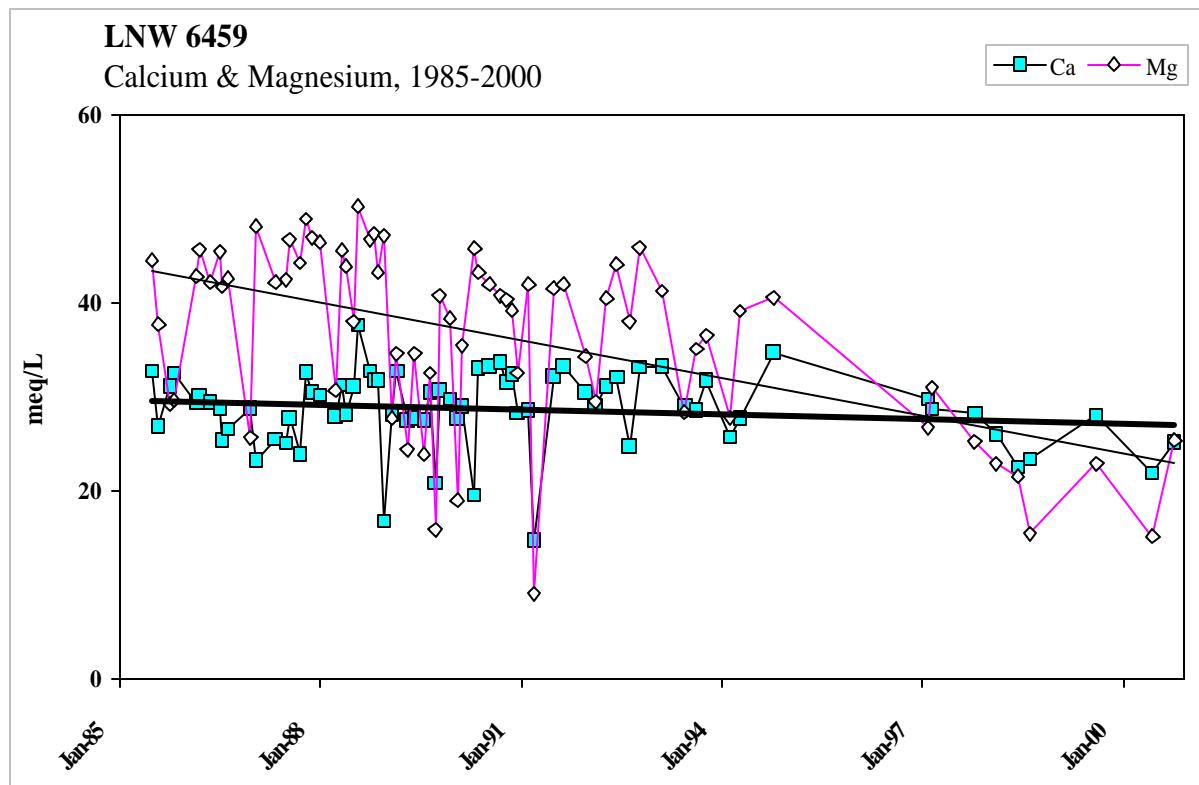
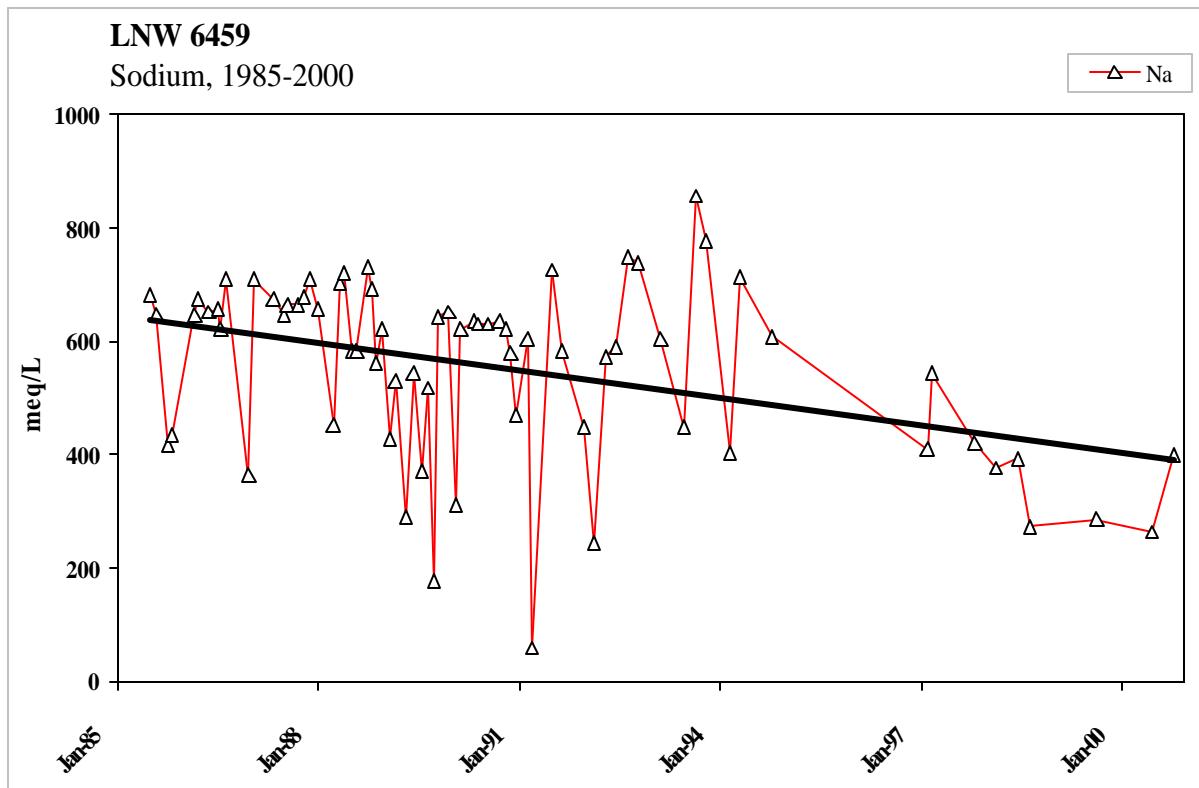
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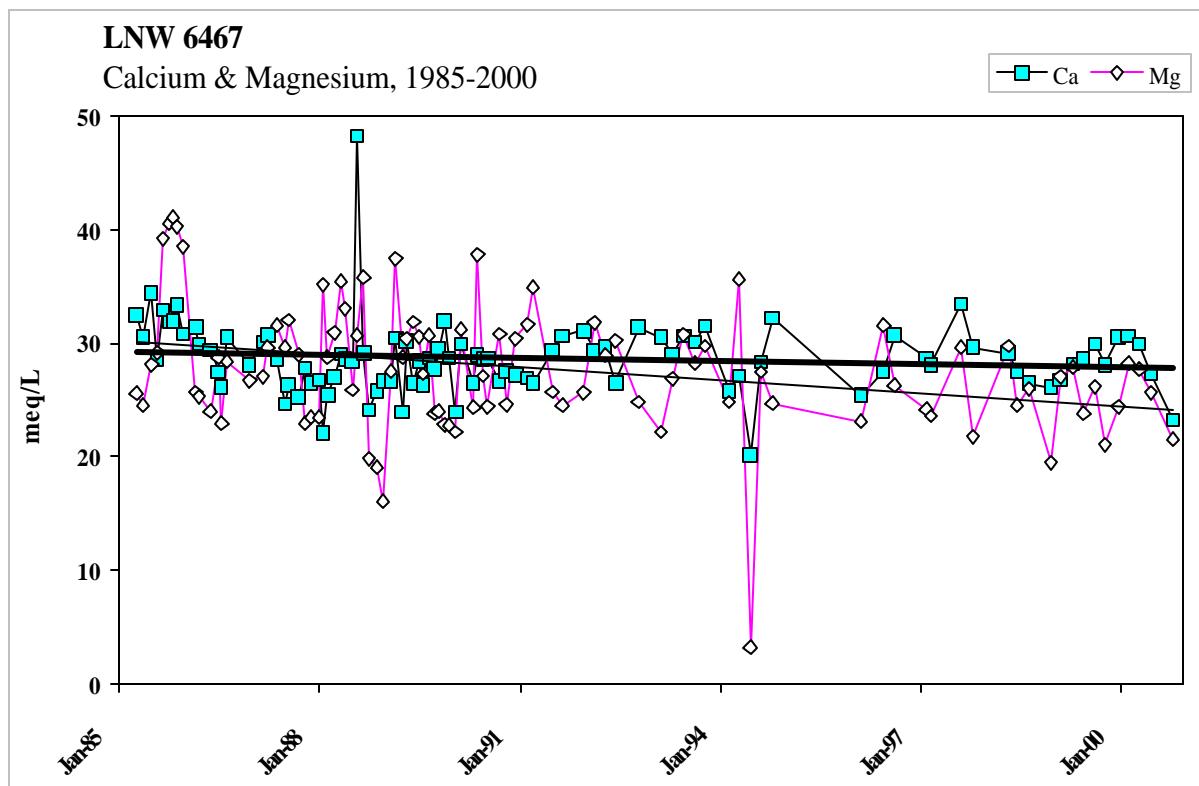
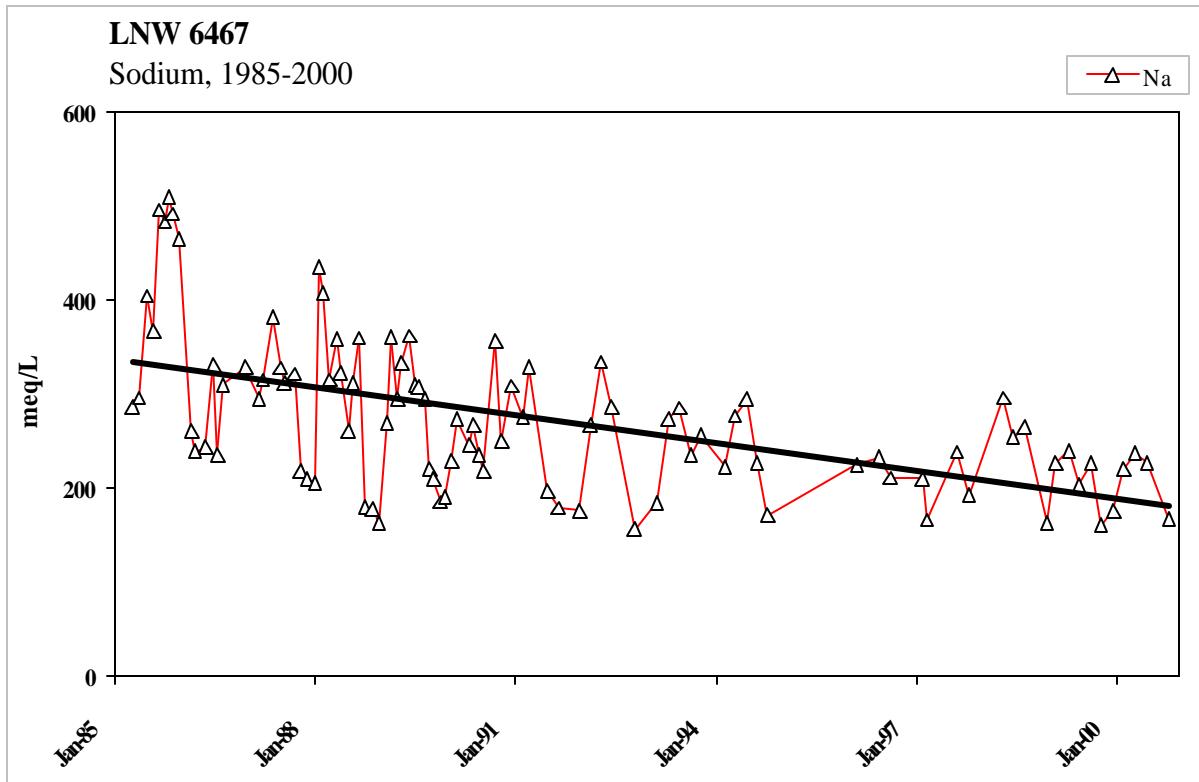
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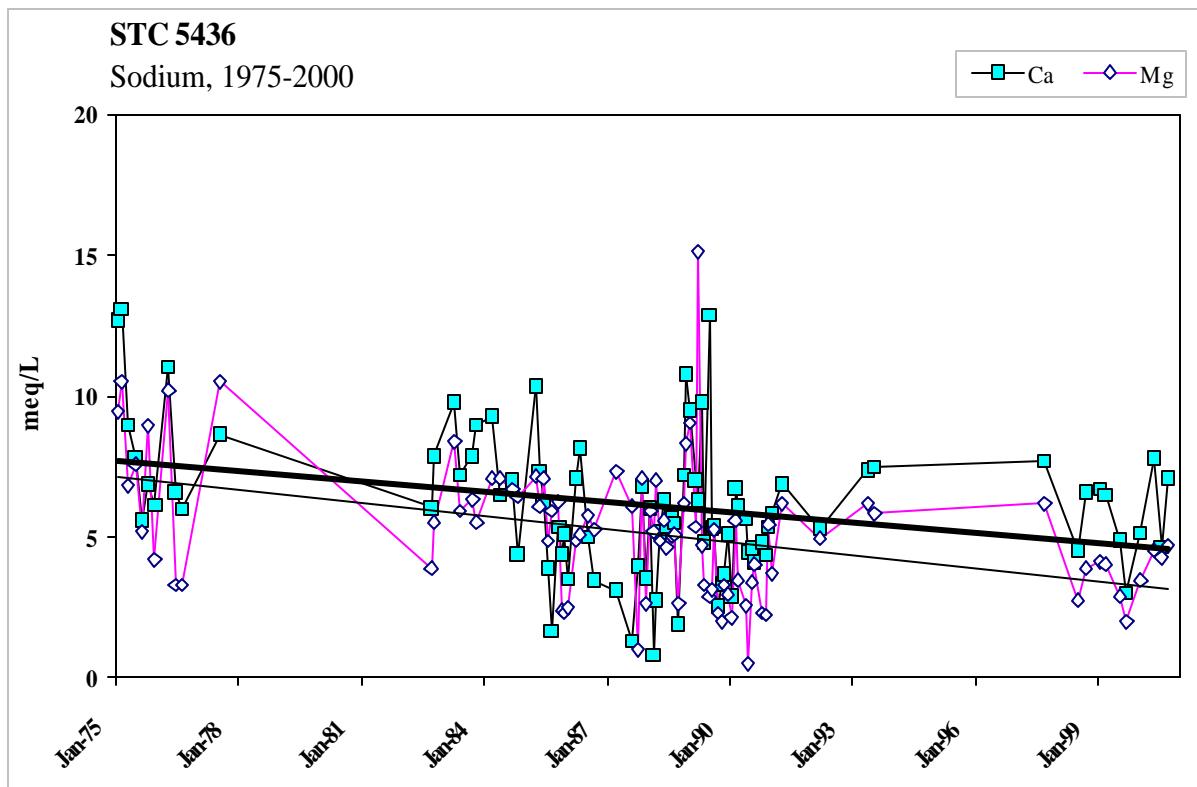
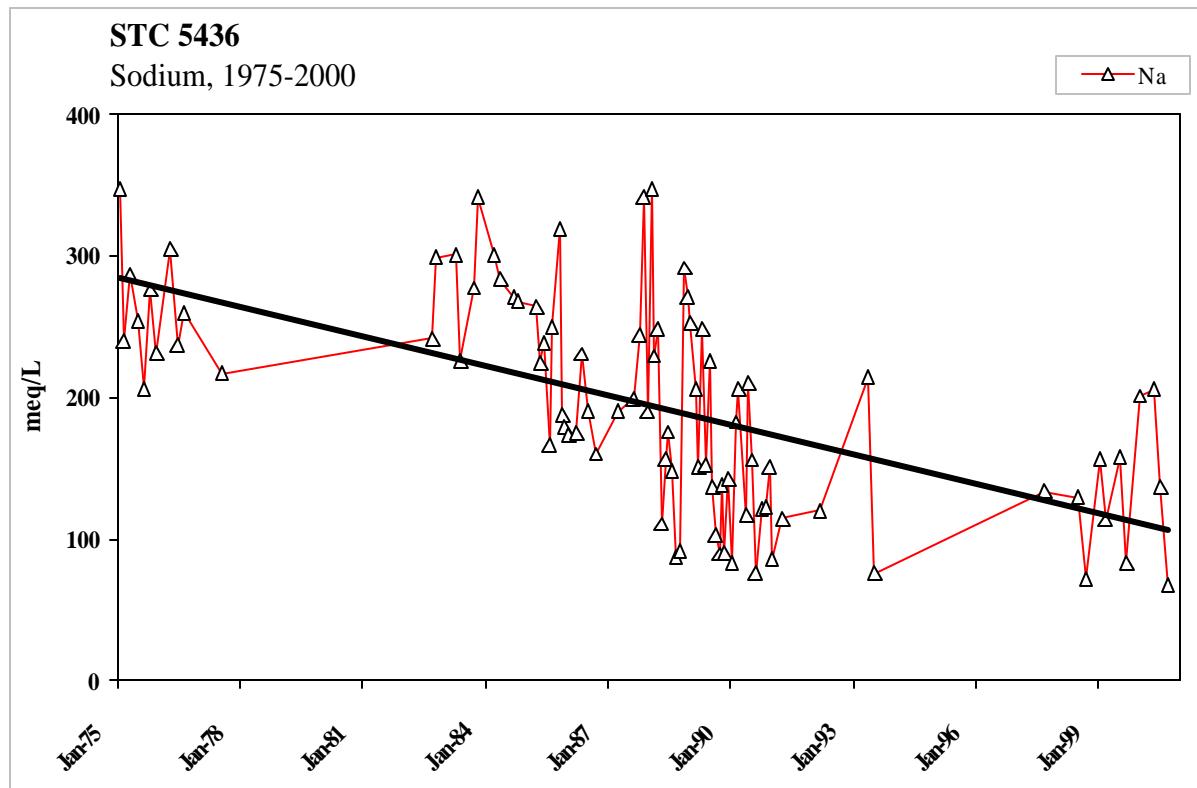
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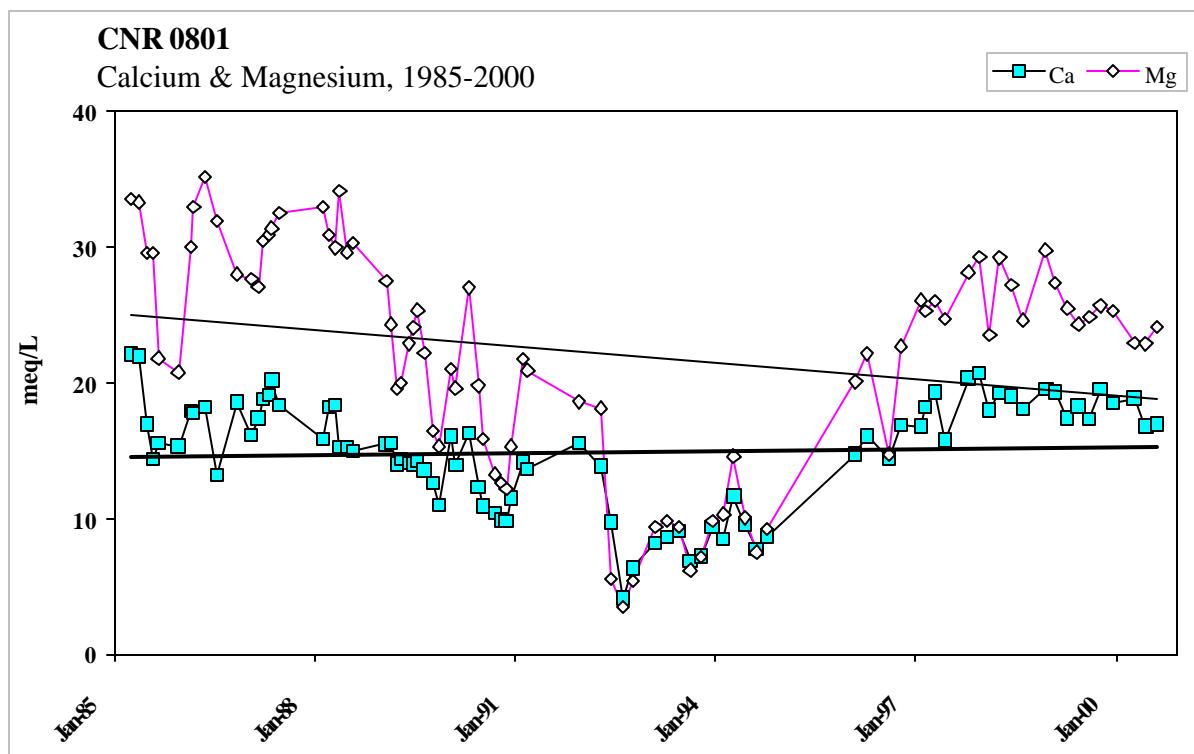
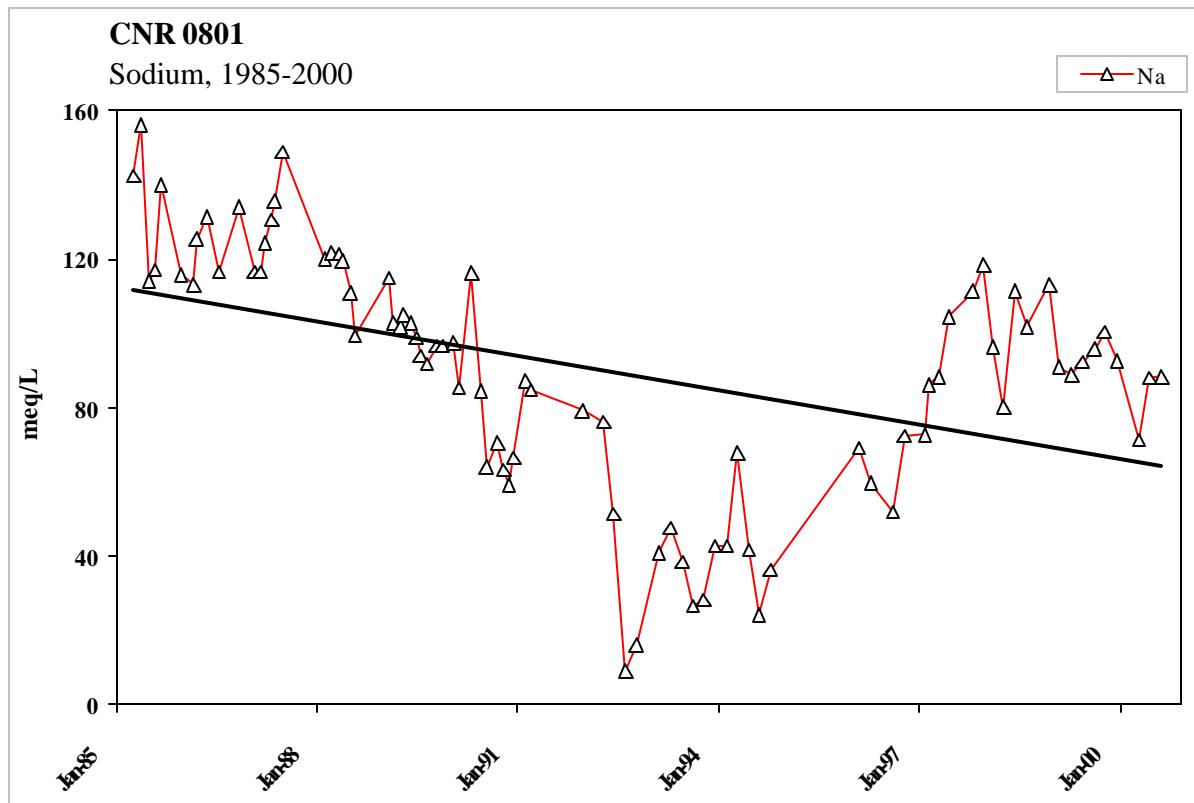
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GRAPHS OF WATER QUALITY CATION TRENDS IN DRAINAGE SUMPS

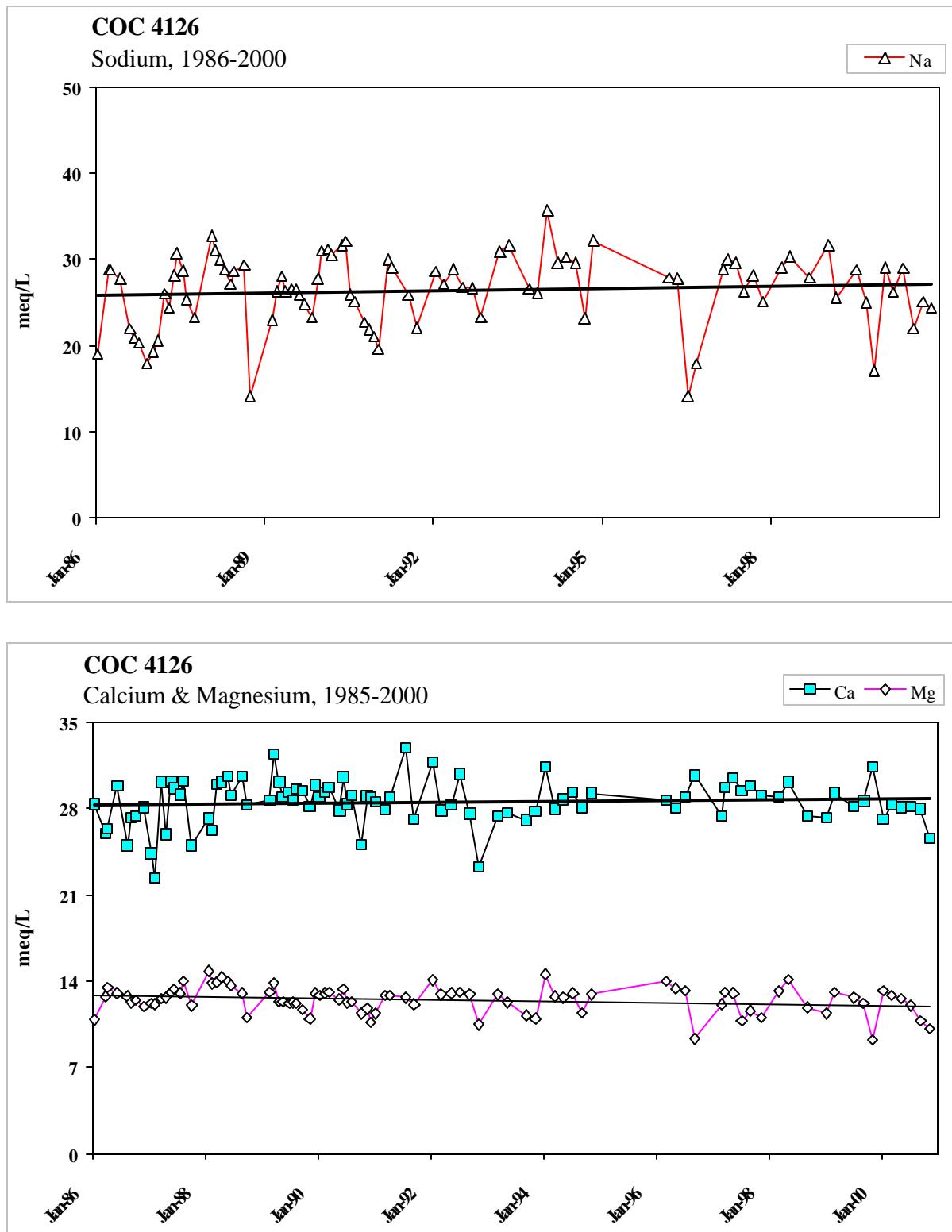
SOUTHERN AREA

KERN LAKEBED STATIONS

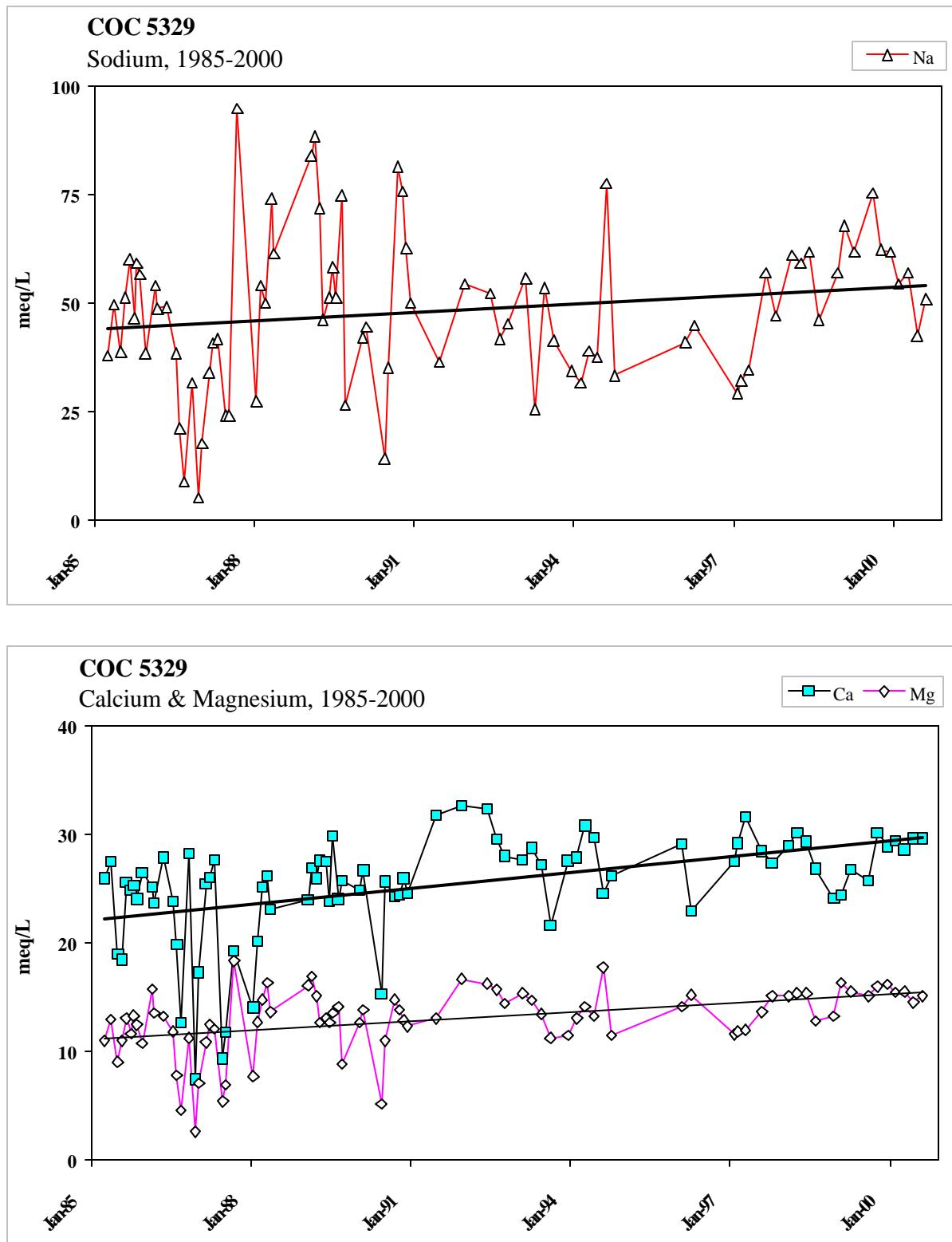
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SYMBOLS, ABBREVIATIONS, AND FORMULAS

Time	Pacific Standard Time on a 24-hour clock
Temp.	Temperature of water at time of sampling in degrees Celsius ($^{\circ}\text{C}$) and degrees Fahrenheit ($^{\circ}\text{F}$)
pH	Measure of acidity (<7) or alkalinity (>7) of water
EC ($\mu\text{S}/\text{cm}$)	Electrical conductance in microsiemens per centimeter at $25\text{ }^{\circ}\text{C}$
TDS	Gravimetric determination of total dissolved solids at $180\text{ }^{\circ}\text{C}$
Mineral constituents:	
B	Boron
Ca	Calcium
CaCO_3	Calcium carbonate
Cl	Chloride
K	Potassium
Mg	Magnesium
Na	Sodium
NO_3	Nitrate (unfiltered)
SO_4	Sulfate
T. Alk.	Total alkalinity
TH	Total hardness
Se	Selenium

Formulas:

SAR Sodium adsorption ratio (developed by U.S. Salinity Laboratory):

$$\text{SAR} = \frac{Na}{\sqrt{\frac{(Ca) + (Mg)}{2}}}$$

Na , Ca , and Mg represent the concentrations in milliequivalents per liter.

Geometric Mean The geometric mean G of a set of N numbers $X_1, X_2, X_3, \dots, X_N$ is the N th root of the product of the numbers:

$$G = \sqrt[N]{X_1, X_2, X_3, \dots, X_N}$$

Legend

- 0'-5' Depth to Free Water
- 5'-10' Depth to Free Water
- 10'-15' Depth to Free Water
- 15'-20' Depth to Free Water
- Extent of Survey
- Study Area Boundaries



METRIC CONVERSIONS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit by	To Convert to Metric Unit Multiply Customary Unit by
Length	millimeters (mm)	inches (in)	0.03937	25.4
	centimeters (cm) for snow depth	inches (in)	0.3937	2.54
	metros (m)	feet (ft)	3.2808	0.3048
	kilometers (km)	miles (mi)	0.62139	1.6093
Area	square millimeters (mm^2)	square inches (in^2)	0.00155	645.16
	square metros (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometers (km^2)	square miles (mi^2)	0.3861	2.590
Volume	liters (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic meters (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic meters (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic decameters (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic meters per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	liters per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	liters per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic decameters per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	liters per minute per meter drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per liter (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimeter (FS/cm)	micromhos per centimeter (Fmho/cm)	1.0	1.0
Temperature	degrees Celsius (EC)	degrees Fahrenheit (EF)	(1.8xEC)+32	(EF-32)/1.8